Ordnance Field Service Number

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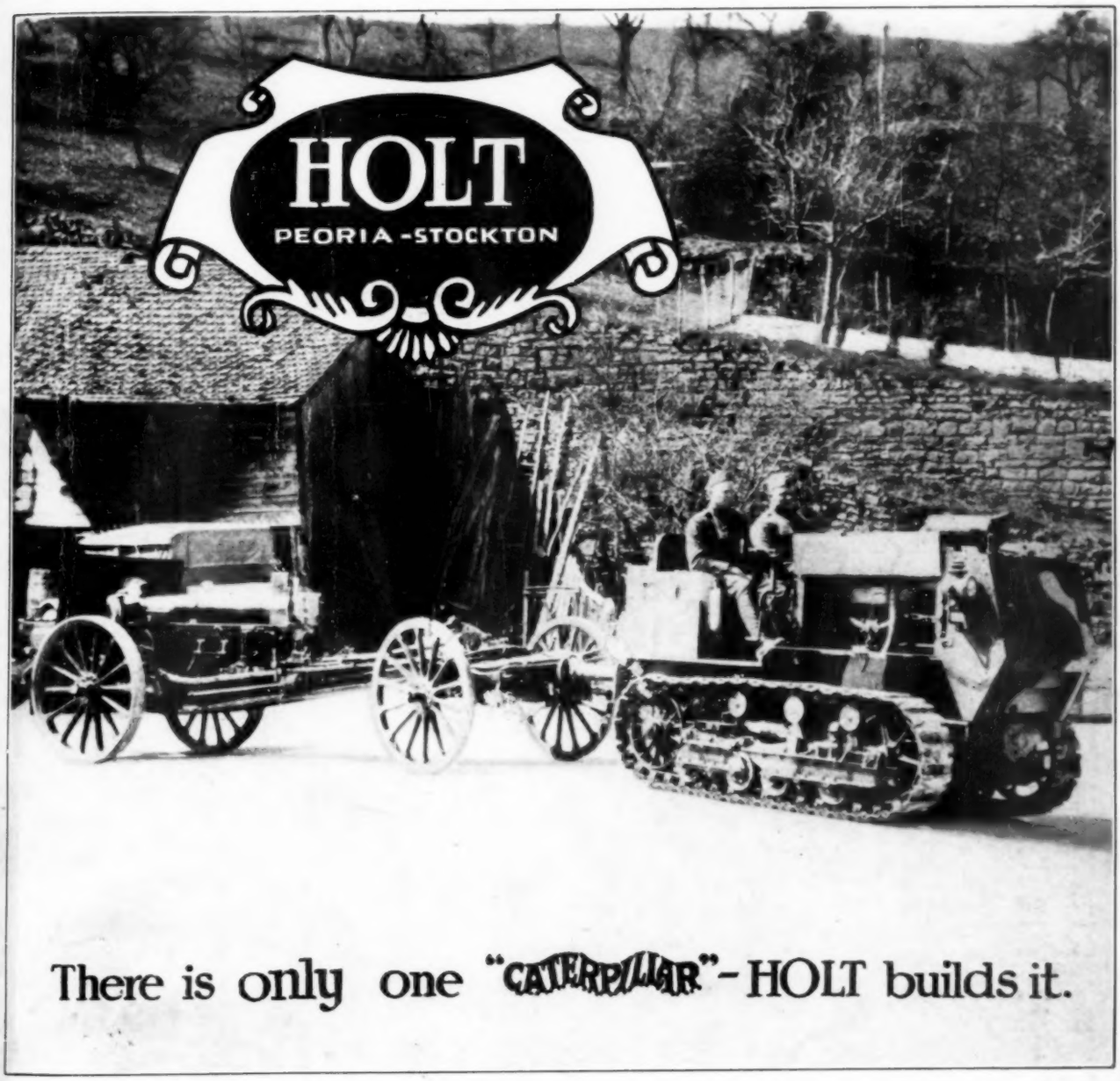

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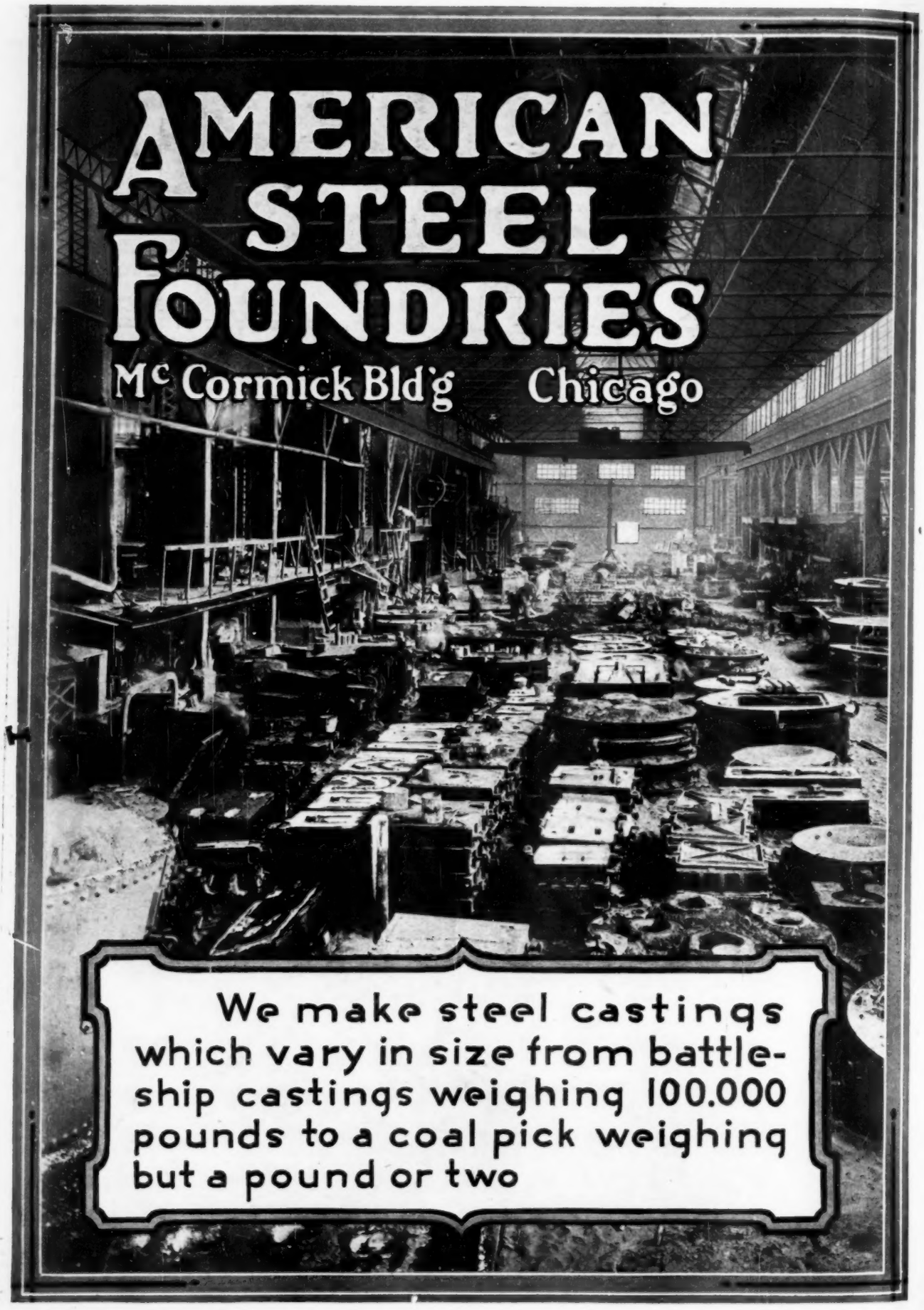

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ARMY ORDNANCE

THE JOURNAL OF THE ARMY ORDNANCE ASSOCIATION

Pledged to Public Service in Effecting Industrial Preparedness for War as Our Strongest Guarantee of Peace

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Swords *and* Plowshares

By

JOHN Q. TILSON
Member of Congress

SCARCELY has the noise of the thundering guns ceased to reverberate along the Meuse before we begin to hear the senseless chatter, time worn and oft refuted, that all wars have now ceased forever. The prophets Isaiah and Micah in identical language foretold the day when men would beat their swords into plowshares and their spears into pruning hooks. This prophecy is now being fulfilled in this country under our very eyes. It was likewise fulfilled after 1865 and again after 1898. In fact, the periodical fulfillment of this beautiful prophecy makes it a somewhat unsafe foundation upon which to build a policy of national defense. Nevertheless we are proceeding upon a theory which for the time being and until war comes fulfills that other prophecy, "Neither shall they learn war any more." Oh, if by simply wishing we could make things so!

According to the teachings of our first President, in peace is the time to make preparation for war. It is for such preparation as I believe our first President would approve of that I speak. Fabulous as has been the cost of our mighty, though necessarily hasty and wasteful, effort to prepare for war in time of war, it will not have been expended in vain if we and those who come after us shall learn from this experience, and not allow to be forgotten the very obvious lessons it has taught.

There were no plans, we are told. The next five years will be the very best years in the century to make plans. The lamp of actual experience, a heart-rendering experience in many respects, will be a light to guide us.

Let me not be misunderstood. I would not maintain a huge Military Establishment in time of peace. In fact, I have always favored a small standing Army, knowing full well that in the future as in the past our wars must be fought by citizen soldiers. For their own sakes as well as for the sake of the country whose defense is their most sacred duty they should have the benefit of an elementary military training; but as I have here tried to show, the most serious obstacle to be overcome by us in the Great War was not the lack of trained man power, important as this was. The mobilization of our industries for the production of munitions was the really big problem. The war lasting 19 months was too short to solve it. The return of peace gives another opportunity to attack the problem in an orderly, systematic, and scientific fashion. The future welfare and safety of the Republic demand that we perform our part of the task now. We of this day and time shall prove ourselves unfaithful servants if without an earnest effort to prevent it we permit ourselves to drift back into the same old fool's paradise in which the war found us.

To prevent such a relapse is not so much a matter of expense as it is of attitude on the part of Congress and the people and of far-sighted, practical making of plans and, so far as may be, carrying them into execution on the part of those charged with responsibility. A tithe of the sum that was wasted in the frenzied effort made during the war if properly expended would go far toward insuring against the possible recurrence of the necessity for such an expenditure. For one, I shall not cease to urge and to assist wherever I may that the house of our national defense be put in order and kept so for the benefit of our own posterity, as well as for the good of all mankind.

(Extract from speech in the House of Representatives, 66th Congress.)

Ordnance Field Service

By

GEO. W. BURR
Member A. O. A.

AFTER having served on detached duty for the past two years the writer but recently returned to duty with the Ordnance Department and was assigned as Chief of the Field Service. From general knowledge, previously acquired, and closer study of the organization in the brief time that he has been in intimate contact with it, certain impressions have been formed which may be of interest.

Brig. Gen. George W. Burr
Chief, Ordnance Field Service

In the period immediately following the armistice, the magnitude of the task of receiving, caring for, storing or arranging for disposition of the enormous quantities of ordnance supplies belonging to the military establishment can can not be visualized or appreciated by one not thoroughly acquainted with the vast extent of the war operations of the Government. At the time of the armistice the country had arrived at the peak of production of war supplies. The demobilization of war industry plants and necessity for promptly clearing these plants of the stores and material on hand to enable them to resume their peacetime production, augmented by the accumulation of stores due to the cessation of shipments abroad, put upon the Ordnance Department a task without parallel in any warehousing activities in history. In addition, the demobilization of the Army and the abandonment of camps and training stations returned to the department for safekeeping and disposition the stocks of stores at these stations and in the hands of troops.

It was during this period that the Field Service was organized as a separate division of the Ordnance Department, and its first duty was the handling of this great warehousing problem. The manner in which the department at large, and its Field Service in particular, performed its mission in this extraordinary situation is a matter of history and reflects unusual credit upon the personnel of the new organization.

The mere problem of providing shelter for the huge accumulation of stores was a stupendous one, but at the present date all Ordnance Department stores are permanently housed or otherwise adequately protected and the department is consolidating and reducing as rapidly as possible and, where necessary, shifting to permanent depots the stores on hand. The task of identifying, classifying, inventorying, cleaning and labeling the stores on hand and received was almost endless, but it has been prosecuted without cessation and to-day is measurably completed.

Millions of square feet of storage space have been acquired and much of this space had to be improvised, but the work has been expeditiously and economically accomplished. Stores to the value of billions of dollars have been handled. In considering warehousing propositions it is usual to refer to the extensive warehouse operations of some of our great industrial or commercial corporations, but the warehousing work of the Field Service in the last two years

has been greater in magnitude than that of many of our largest industrial corporations combined.

However, the unusual nature of the work arises not from its magnitude but from the character of the emergency conditions under which it was carried on—the lack of storage facilities, the lack of definite knowledge of requirements, the lack of sufficient trained personnel with knowledge of the material to be stored—all of these conditions made the task so unusual and so extraordinary that its efficient accomplishment must be regarded as a marvel in this particular line of work. It could not have been so efficiently accomplished without the continued, devoted and untiring efforts of the personnel connected with the Ordnance supply service. Many of the devoted officers and civilians who were concerned in this work are now out of the service, but to them, as well as to those remaining in the service, in the last analysis must be given the credit for the results attained. The writer feels that he is free to pay this deserved tribute to the personnel of the Field Service because, at the time under discussion, he was not connected with this service.

The Field Service has in its storehouses much reserve material of an unusual character which must be stored so as to be readily accessible for examination and the care necessary for preservation. The methods of storage of bulky articles such as guns, carriages and other vehicles, so as permit such examination and reconditioning without excessive handling and with necessary space economy, have been the subject of much study. In many of the storehouses original and noteworthy methods of compact, accessible storage of such articles have been worked out, and the originators of these methods* may well be proud of their work. In fact, some of these warehousing methods are models well worthy of the study of any expert in such matters.

An impression gained by the writer in the short time that he has been on duty in the Field Service has reference to the relations already established between the Field Service and the agencies of other branches of the Army with which it has to deal. The establishment of the Field Service as a separate major division of the Office of the Chief of Ordnance brought together under one head vital functions and duties of the Ordnance Department. The Field Service, as its name implies, is concerned with the operations of the Ordnance Department in the field. It is the point of contact, the connection, between the Ordnance Department and the rest of the Army. In this contact its duty is one of service. Its primary reason for existence is to serve the troops promptly and efficiently in all matters of supply and maintenance confided to its charge. The efficiency of the troops depends in large measure upon the manner in which the Ordnance Field Service performs its duties and in the Army at large the reputation of the Ordnance Department is almost entirely dependent upon the efficiency of its Field Service. It is essential that this relationship be kept in mind.

The Field Service is, in many respects, similar to a large commercial organization serving the needs of a certain line of business. It provides its services, and its success depends upon the quality of those services. If satisfactory to those served, it secures their good-will and approval and its future relations with them are made easier because of the favorable impression thus established. In this way mutual understanding and confidence beget harmony and harmony promotes efficiency. From the beginning the Field Service has earnestly endeavored to cooperate with and be of use to the Army, the National Guard and others it serves; and to this attitude of helpfulness and to the sympathetic relations resulting therefrom must be attributed in large measure its success in the past. The mutual understanding and cordial relations already established with those with whom it does business constitute to-day its most valuable asset and the continued cultivation of this sympathetic attitude must be the foundation for its usefulness in the future.

This happy relationship is, of course, merely a concrete expression of the settled policy of the Chief of Ordnance to invite and encourage on the one hand a sympathetic understanding with the department's patrons in the military service, whether Regular Army, National Guard or other user of ordnance material, and on the other hand to foster similar relations with American industry, upon which the department, in emergency, is dependent for supplies. His policy of insisting upon consideration of the human element in all of the department's relations has gone far to promote efficiency and harmony and has made easier the Ordnance officer's work. It is a pleasure to record here the fact that the Field Service is a thorough believer in this policy, has in the past adhered to it with great success and will consistently follow it in the future.

[*Description of some of the unique warehousing methods developed by the Ordnance Field Service will be printed in later numbers of ARMY ORDNANCE.—ED.]

[General Burr's first service was in the Artillery; after 5 years he was transferred to the Ordnance where, as a subordinate, he served at Allegheny, Rock Island and Watervliet Arsenals and Sandy Hook Proving Ground. During this time he was actively connected with the design and the manufacture of the Model 1902 Field Artillery material used in the service for many years.

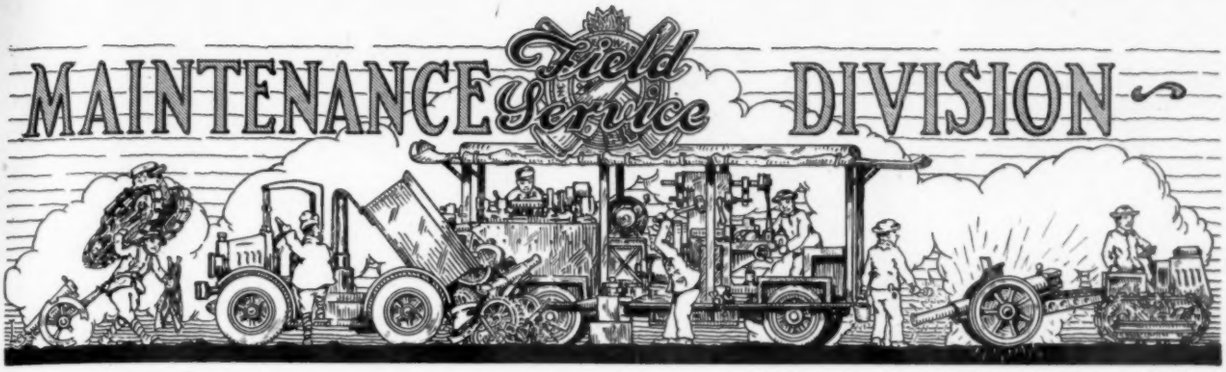
He was Commanding Officer, Manila Arsenal, and Chief Ordnance Officer, Philippine Division, 1907-10; Commanding Officer, Augusta Arsenal, Georgia, 1910-11; and Commanding Officer, Rock Island Arsenal, 1911, to February, 1918.

From February to October, 1918, he was Chief Ordnance Officer of American Forces in England and representative of the Ordnance Department with the English Government. He returned to Washington, D. C., in October, 1918, and was assigned to duty in the Ordnance Office as Chief of the Engineering Division.

In November, 1918, he was assigned to duty in the Purchase, Storage and Traffic Divisions of the General Staff as Assistant Director, and on March 1, 1919, was appointed Assistant Chief of Staff and Director of the Purchase, Storage and Traffic Division of the General Staff in succession to Maj. Gen. George W. Goethals. Here, in addition to supervision of army supply work proper, he was in general charge, under the Secretary of War, of questions relating to demobilization of war industry, disposition of surplus property and settlement of war contracts. He continued in that position until relieved at his own request on September 1, 1920, in order to return to duty with the Ordnance Department.

Upon relief from duty with the General Staff, General Burr was sent abroad as Special Representative of the Secrtary of War to close up War Department liquidation matters abroad and in that capacity concluded a contract by which the war business of the War Department with the various departments of the English Government was settled.

He was assigned to duty as Chief of the Field Service of the Ordnance Department, December 16, 1920.—ED.]



Ordnance Maintenance

By

KENNETH B. HARMON
Member A. O. A.

[Colonel Harmon was in command of the largest Ordnance Depot on the Mexican Border when the U. S. entered the World War. Due to his experience in supplying ordnance to troops in the field, as well as maintaining in serviceable condition that already issued, he was selected by the newly appointed Chief Ordnance Officer of the American Expeditionary Forces to organize and take to France the first unit of ordnance maintenance personnel to be sent overseas. For his highly efficient work in connection with the solving of problems connected with the establishment and operation of the supply and maintenance system of the Ordnance Department of the A. E. F., and in establishing first a base Ordnance depot, then an intermediate depot and later on an advance depot, he was awarded the Distinguished Service Medal by General Pershing.—ED.]

PAST wars have been fought with weapons of such simplicity that very limited repair facilities were required with an army. Prior to the World War each company took into the field a small box containing an assortment of spare parts and a few simple tools with which the company mechanic repaired the rifles and pistols. Each battery of field artillery had a store wagon, a battery wagon, and a forge limber containing a variety of spare parts and special tools including a blacksmith's outfit which was used chiefly for shoeing horses.

In recent years much progress has been made in the development of more effective weapons, a variety of new weapons has been added and motor vehicles introduced as substitutes for horses. Most of these changes have been attended by increased intricacy of design and complexity of construction. During the World War this development went forward at a remarkable rate, and there is every indication that the next war will be, to a still greater extent, a war fought with mechanical devices. Consequently in our most recent war it was necessary, and in future wars it will be even more necessary, to provide extended facilities for the repair of the equipment used by troops.

The equipment of our armies is furnished by several staff departments—the Quartermaster Corps supplies food, shelter, clothing and facilities for general transportation by water, rail and road; the Medical Corps furnishes medical supplies; the Signal Corps furnishes facilities for communication; the Engineer Corps furnishes engineering supplies, but almost entirely for its own use; and the Ordnance Department furnishes weapons. The Air Service supplies its own flying equipment, but the Ordnance Department provides the armament. From this it is seen that a greater part of the mechanical equipment with combat troops, except the Air Service, is furnished by the Ordnance Department. In fact, the only other mechanical equipment of importance is the motor transportation.

It goes without saying that the Ordnance Department should furnish the facilities and personnel trained for the maintenance of the equipment it issues, and due to the preponderance of Ordnance equipment it appears desirable to charge this department also with the repair of equipment issued by other departments, since more than one system of shops in the combat zone is neither desirable nor economical. The repair facilities for the flying equipment of the Air Service are of such a special nature and so extensive that they do not lend themselves readily to combination with the other repair facilities of the army, and they are exempted from the statements in this paragraph. The armament of the planes is, however, maintained by the Ordnance Department. At present the field repair shops are actually operated by the Ordnance Department, and these shops are charged also with the maintenance of all automotive equipment with artillery brigades, including that furnished by the Motor Transport Service of the Quartermaster Corps. The one disadvantage of this system is that no single service is responsible for the successful operation of the motor transport equipment. The Motor Transport Service is dependent upon the Ordnance Department for proper maintenance of motor transport vehicles, and the Ordnance Department at the same time is dependent upon the Motor Transport Service for the supply of necessary spare parts. The fault in such a scheme of organization is obvious and can be minimized only by close supervision and co-ordination by the General Staff.

It has been suggested that both the supply and maintenance problems would be simplified if all motor equipment were handled by the Ordnance Department. This solution seems to be a practicable one, even if transportation is operated by a separate corps in time of war, because the Ordnance Department would bear to it the same relation it bears to other branches of the service—it would design, manufacture (or procure), issue, and maintain the equipment. This discussion, however, is foreign to this subject and we will proceed with a discussion of maintenance under the conditions which now exist.

Probably the first step by the Ordnance Department in extending maintenance facilities with troops was the issue of an artillery repair truck, equipped with machinery, to

"C" Battery of the 5th Field Artillery at El Paso, Texas, in 1916. This was while General Pershing's expedition was in Mexico and large forces were mobilized in Texas. At about the same time the Ordnance officers at Columbus, N. M., El Paso, San Antonio and Harlingen, Texas, improvised mobile repair shops by constructing special bodies on ordinary trucks. With these they were able to effect repairs to equipment with troops at a distance from the base. With our first division which sailed for France, there was provided a complete small machine shop of a portable nature but not strictly mobile. Later on, as it became available, mobile equipment was provided and all of our divisions went into action accompanied by good mobile ordnance repair shops. By the time the Armistice was signed equipment was being received in France of such a character that our shops were far superior to any provided by other nations. Two kinds of shops were used at that time—one, a light shop for divisions and known as a Mobile Ordnance Repair Shop; the other, a heavy shop, of which there was only one in France, for assignment to brigades of heavy, motorized artillery, and known as a Heavy Artillery Mobile Ordnance Repair Shop. The value of this latter shop is about half a million dollars, based on war-time prices, and it constitutes a very complete machine shop. The Light and Heavy Maintenance Companies, hereafter described, are the outgrowth of these mobile shops. Following the war there was established in the Ordnance Department a Field Service to perpetuate as a distinct function the activities of that Department with troops in the field.

Ordnance Light Maintenance Company in the Field

A Normal War Organization with an Expedition

One of the three divisions of Ordnance Field Service is the Maintenance Division. It is so called because it is charged with the *maintenance* of ordnance material—particularly that which is in the hands of troops. To do this work there are provided "Maintenance Companies" with divisions, corps, and armies, as well as in the communications zone in rear of the armies. These companies are provided with mobile or fixed machine shop equipment according to their assignment.

The nature of the work may be understood from a statement of the principal equipment which must be maintained. A brief summary showing the variety and kinds is as follows:

Artillery material, including guns of all kinds and calibers from the 37-mm. infantry gun up through the 75-mm. field gun, and the 155-mm. howitzer to the largest 16-inch railway guns with their carriages;

Small arms, including rifles, automatic rifles, machine guns, pistols, revolvers and pertaining equipment;

Fire Control Instruments, including all the delicate optical and measuring instruments, field glasses, watches, etc.;

Automotive Equipment, including the 6-ton Renault type tank, the 30-ton Mark VIII tank, the 5 and 10-ton tractors and all the automobiles and motor equipment of various kinds used by artillery brigades;

Aireraft Armament, that is, aireraft machine guns.

From this it is evident that a very comprehensive shop equipment is required to enable the "Maintenance Companies" to meet the demands made upon them.

The scheme of assigning the maintenance companies follows the normal organization of the army into tactical units. The smallest and most mobile maintenance companies are assigned to divisions, heavier (but still mobile) companies are assigned to the corps troops and to the army troops. In rear of these are "advance base shops" permanently located and still further to the rear are the "base shops." In the case of an expedition based primarily on points within the United States—such as an expedition into Mexico or Canada or a defensive operation—our permanent arsenals would constitute the "base shop," and the advance base shops would be established at points near the border or at ports of embarkation. However, in the case of an overseas expedition, it is necessary to establish both the advance base shops and the base shops on territory (either friendly or hostile) outside the United States. In the recent war with Germany our "Base Shops" were at Mehun and our "Advance Base Shop" at Is-sur-Tille—both in France. In addition to the above there are provided maintenance companies to care for auxiliary troops, etc., and these will be mentioned later.

A brief description of the maintenance organization, the equipment and work, beginning at the front line and working to the rear, follows:*

The Infantry Division

A typical infantry division may be said to consist of two brigades of infantry and a brigade of artillery plus certain auxiliary troops. The principal Ordnance equipment to be maintained is:

17,000 rifles,
1,200 machine guns and automatic rifles,
13,000 pistols and revolvers,
48 75-mm. guns,
3,400 instruments,
12 37-mm. guns,
144 caissons,
15 tanks.

For this work there is assigned to each division an Ordnance Light Maintenance Company with a war strength of

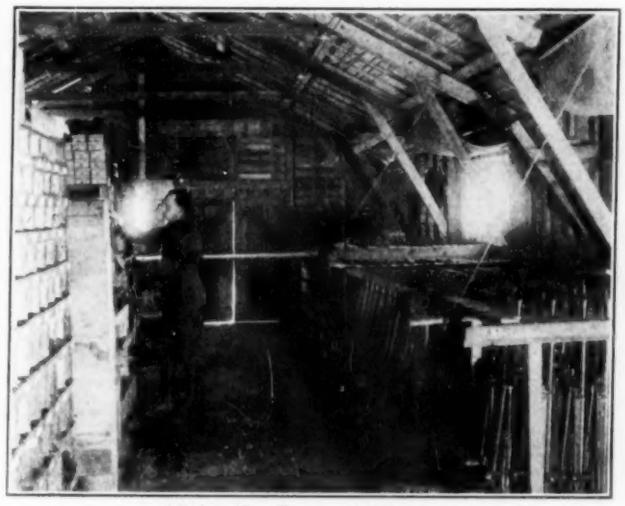
*Note.—It should be noted that the system here described is slightly different from that used during the recent war. The remarkable success achieved by the Divisional Mobile Ordnance Repair Shops led to a careful study of their organization. Based on the recommendations submitted by their commanding officers the equipment has been modified, the personnel increased, the function of supply of parts added and the name changed. The organization here described is now under consideration by the General Staff.

seven (7) officers and one hundred and five (105) men. The company contains a headquarters and supply section which handles the issue of ordnance property to the division, does the office work, and runs the mess for the company. There is also a service section which maintains and operates machines for all purposes required. Then there are special sections to handle the artillery repairs; the tank, tractor, and automobile repairs; and the small arms repairs. The following table shows the internal organization of the shop:

Ordnance Light Maintenance Company

	Officers	Enlisted men
Headquarters and Supply Section	1	21
Service Section	1	18
Artillery Section	2	26
Automotive Section	2	25
Armory Section	1	15
Total War Strength	7	105

The variety of trades required even in this, the smallest shop, should be noted—machinists, gun mechanics, armorers, tank experts, tractor experts, welders, auto-repairmen, leather workers, carpenters, electricians. Reference to the illustrations will give a good idea of the equipment furnished the Ordnance Light Maintenance Company. In operation, this company forms part of the division and accompanies it to a point near its position in the line. Unless there is unusual protection, the enemy artillery will not permit a shop to operate successfully very close to the front line. There was at least one case in France where one of our shops was forced by enemy shell fire to abandon its position. It is very difficult for men to do good machine work or delicate repairs under fire. More courage is required for this than in circumstances where they can fight back. Roads leading from the troops to the position of the maintenance company are marked with sign boards indicating the route so that no time need be lost in locating the shop.



Machine Gun Center at Void, France

The light repair trucks are used to send squads of repair men to the organizations at their positions in the line so that minor repairs may be made there with little or no loss of time. The efficiency of a maintenance company is measured by how nearly it succeeds in keeping 100 per cent o the fighting equipment in serviceable condition throughout an engagement. To this end the maintenance company periodically must call guns, tanks, etc., out of service during periods of quiet for general overhaul and thus prevent breakdown which otherwise might occur during action. When such precaution is taken the division may begin an engagement with all of its equipment in excellent condition, and with the greatest practicable probability of no serious defects developing during the engagement except those due to enemy fire.

The company, in selecting its site, takes advantage of such housing facilities as may be available, and does not confine itself to the shelter afforded by its trucks except when no suitable buildings or tents are to be had. Rude sheds are frequently constructed from such material as can be picked up, so that gun carriages, tanks, tractors, etc., may be disassembled and repaired under cover. The machine equipment is never removed from the trucks, because the company must be ready to move with the division at a moment's notice. With the sides and tail-gate down and the side and tail curtains extended to form a roof, the truck itself constitutes a very satisfactory small machine shop. It may be jacked up off the springs to reduce vibration. The maintenance company habitually carries two spare 75-mm. guns and carriages for use as substitutes for guns undergoing repair or rendered permanently unserviceable.

The limit to the work undertaken by an Ordnance Light Maintenance Company depends on two factors—its equipment, and the time available. When the damage is too serious to be repaired by the facilities in the Ordnance Light Maintenance Shop, the article is sent to the advance base shop, and if necessary, from there on back to the base shop. If the damage is slight but the use of a large machine is required, the article may be taken to the Ordnance Heavy Maintenance Company assigned to the Corps. In the scheme of operation the corps shop is intended to back up the divisional shop in only this respect, and the bulk of the work going to the rear from the divisions should go directly to the advance base shop.* During an offensive some jobs which could readily be handled in the Ordnance Light Maintenance Company must be sent to the rear on account of the long time required to do the work, and because there are many short jobs coming in. The division commander has no discriminative interest in any particular gun but wants that one repaired first which can most quickly be gotten back into action. Priority of work should be regulated on this basis.

The Corps

A typical corps may be taken as consisting of three infantry divisions and certain auxiliary troops known as "Corps Troops," which may be assumed to consist of:

1 Brigade of 155-mm. howitzers, motorized, including
  72 155-mm. howitzers,
  180 5-ton tractors,
  125 trucks and autos,
  216 caissons.

*Note.—In the system of maintenance it is essential that the greatest possible flexibility exist and there must be no hesitation in deviating from normal procedure if it is advantageous to do so. Perfect service to the fighting troops is the only condition to be satisfied and everything not contributory must be sacrificed to this end. Care should be taken to guard against accomplishing this at the expense of other fighting troops. It occasionally happened in France that one division accumulated so many spare guns in its effort to keep its full equipment always serviceable that other divisions had to get along with less than their proper allowance. The supply of guns is always limited.

1 Regiment of 155-mm. guns, motorized,
  24 155-mm. guns,
  24 10-ton tractors, etc.
1 ammunition train,
6 truck companies,
1 anti-aircraft regiment,
12 75-mm. guns,
26 airplanes.

In addition to the three Ordnance Light Maintenance Companies with the divisions, there are provided with the "Corps Troops" one Ordnance Light Maintenance Company for the Howitzer Brigade, and one Ordnance Heavy Maintenance Company for the remaining "Corps Troops" listed above and to back up in a limited sense the divisional maintenance companies. So we have with each corps a total of one (1) Ordnance Heavy Maintenance Company, and four (4) Ordnance Light Maintenance Companies. The light company assigned to the howitzer brigade forms an integral part of the brigade, accompanying it and serving it only. The heavy company is used by the Corps Ordnance Officer to discharge his obligations in the most satisfactory manner possible. This shop is generally fixed in location so long as the corps occupies the same area. It is available to the divisional companies for the performance of heavy machine operations. Also under desirable circumstances it may be used as a medium for supplying spare parts to the divisional companies.

Repair Truck for Small Arms and Equipment

The organization of the Ordnance Heavy Maintenance Company is similar to that of the Light Company, but on a larger scale, as follows:

Ordnance Heavy Maintenance Company

	Officers	Enlisted men
Headquarters and Supply Section	2	42
Service Section	2	53
Artillery Section	2	71
Automotive Section	2	69
Armory Section	2	53
Total War Strength	10	288

The equipment includes medium-sized machines mounted on individual trucks or trailers, as shown in accompanying illustrations. To preserve mobility the machines should not be removed from the chassis. The operation of the heavy company is similar to that of the light company, but on a larger scale and with more varied functions.

The Army

An Army may be said to consist of three (3) Corps plus certain auxiliary troops called "Army Troops." In the army troops according to the organization here assumed there are an anti-aircraft artillery brigade, an attack wing of air troops and three (3) cavalry divisions. A light maintenance company is provided for the artillery brigade, one for the attack wing and one for the three cavalry divisions. A fourth light company is provided to serve as an army machine gun center. It carries a large stock of machine guns and spare parts and is the distributor to all troops in the army. It may or may not act in conjunction with the army depot. Adding these facilities to those in the three (3) corps, gives a total of three heavy and sixteen light maintenance companies for an army.

General Headquarters

The General Headquarters functions for an army or a group of several armies. It has for distribution or for direct operation a large quantity of artillery—some light, but mostly medium and heavy—all of which is motorized or railway artillery. That artillery for distribution among the armies may consist of two (2) brigades of light artillery and one (1) very large brigade of mixed medium and heavy artillery for each army in the expedition. For the former two (2) brigades there are provided two (2) Ordnance Light Maintenance Companies, and for the latter brigade two (2) Ordnance Heavy Maintenance Companies. The artillery for direct operation may be assumed on the basis of six (6) armies, to include three (3) regiments of railway artillery and trench mortars, eighteen hundred (1800) tanks, an attack wing of two hundred and sixty (260) airplanes and an assortment of smaller units. Three Ordnance Light Maintenance Companies are required for the artillery, and six (6) Ordnance Heavy Maintenance Companies for the tanks. One Light Company is required for the attack wing and another for the miscellaneous small units. On this basis, the complement of maintenance companies for the General Headquarters reserve is seventeen (17) light and eighteen (18) heavy; and the aggregate for an expedition of six armies is one hundred and thirteen (113) light and thirty-six (36) heavy companies with a stotal strength of eleven hundred and fifty-one (1151) officers and twenty-two thousand two hundred and thirty-three (22,233) enlisted men. These figures include only the facilities with the fighting troops.

Summary of maintenance facilities with the troops of an expedition of six (6) armies:

	Light companies	Heavy companies
General Headquarters Reserve	17	18
Army troops (6 armies)	24	--
Corps Troops (18 corps)	18	18
Divisions (54)	54	--
Total	113	36

These provisions for maintenance are for a particular assumed expeditionary force. The proper provisions for any body of troops may be arrived at approximately by providing companies as indicated below:

One Ordnance Light Maintenance Company to be assigned
  to each infantry division,
  to each cavalry division,
  to each brigade of motorized 75-mm. guns or 155-mm. howitzers,
  to each wing of air troops,
  to each "Army Troops' as a machine gun center,
  to each regiment of railway artillery.

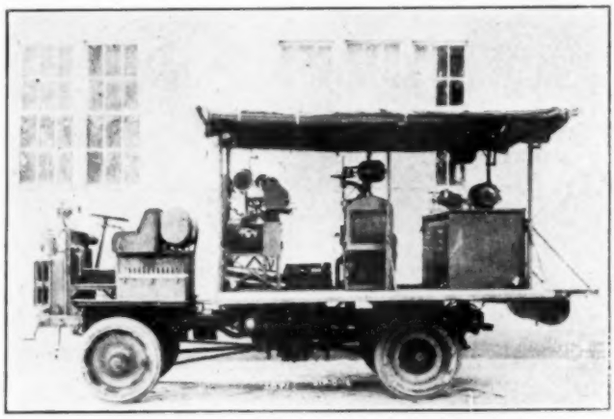
One Ordnance Heavy Maintenance Company to be assigned
to each "Corps Troops,"
to each brigade of heavy motorized artillery,
to each group (about 300) of tanks.

The Advance Base

The advance base is located as far forward as safety of its stores and suitable railway facilities will permit. It is roughly speaking, as near to the enemy as it is wise to construct permanent shops and storehouses. There may be one or more advance bases depending on the communications and the extent of the front. The number of Ordnance Heavy Maintenance Companies stationed at an advance base and the size of the repair shop depend upon the number of troops served by them. In general there would be one (1) heavy company per army of nine divisions. This shop undertakes extensive repairs on light and medium artillery, tanks, tractors, etc.

The Base

The base is the main accumulation of supplies for distribution to the armies through the advance bases. In France the distance from the seaboard to the advance base was so great, and the capacity of any one port so limited, that it was necessary to establish an Intermediate Base about half way from the ports to the advance base. Therefore, there was a so-called "base" at each port; but the supplies from them all were concentrated at the "Intermediate Base." The "base repair shop" in this case was located near the intermediate base. Base shops are capable of undertaking any repair work, including the relining of guns and also the limited manufacture of spare parts. These shops are intended primarily for major repairs on heavy ordnance material and for large quantity repair on small arms, etc., too far gone to be economically repaired further forward. The enormous extent of such shops may be appreciated when consideration is given to the large caliber railway artillery, tanks, etc., which they must handle. The Ordnance Base Shop at Mehun, France, employed at one time over 3,000 men, although this shop was only partially complete, due to the early armistice. A reasonable initial assignment of Ordnance Heavy Maintenance Companies to a Base Shop would be at the rate of two companies per army of nine divisions.



General Machine Truck for Light Maintenance Company

Incidental maintenance activities in the communications zone include in addition to the base shops and advance base shops, a great number of smaller shops at all of the various training and replacement camps, and several training schools for officers and enlisted men to fit them for maintenance work at the front. In France small shops were operated for maintenance of artillery at Coetquidan, Meucon, Souges, Valdahon, La Courtine, Clermont Ferrand, Haussimont, Libourne, Limoges and Saumur; for machine guns and small arms at Langres and Gondrecourt; for aircraft armament at Paris, Orley Field and Ramorantin. Schools on artillery material were operated at Valdahon and Is-sur-Tille; a small arms and machine gun school was at Is-sur-Tille; and an aircraft armament school was at St. Jean de Mons. All these taken in addition to the large Advance Base Shop at Is-sur-Tille and the enormous Base Shop at Mehun give some idea of the magnitude and extent of the work.

The Supply of Spare Parts

Distribution and supply of spare parts require careful consideration. So long as parts exist in abundance little difficulty is experienced and almost any system will work. But this is seldom the case; and the supply department is usually confronted with the problem of reaching a happy compromise between the desirability of having generous supplies with the troops and the necessity of retaining supplies in warehouses for the fulfillment of requisitions. Supplies with troops are out of control and cannot be diverted from one organization to another sorely in need. Hence, over distribution is a danger. Taking artillery spares for an example, the batteries should carry very few spares, but the Ordnance Maintenance Company should have a good variety in small quantities to enable it to meet any demands by the batteries. The stock in the Ordnance Maintenance Company is kept up by daily requisition to replenish its daily expenditures. Under ordinary circumstances the supplies for the maintenance companies are obtained from the Army Depot, one of which is maintained in each army area. But if the distance from the advance base to the front line is short, say 15 or 20 miles, and transportation facilities good, then all maintenance companies may be supplied directly from the Advance Base. On the other hand, if the distance is great, the Army Depot will be used and the Ordnance Heavy Maintenance Company in the Corps Troops may at the same time be an intermediate distributor to the corps and divisional maintenance companies.

Staff Personnel

To control the operation of the system here described for an expedition, there is provided a staff of ordnance officers distributed as follows, each with jurisdiction parallel to that of the general officer on whose staff he is serving:

For the entire expedition, a Chief Ordnance Officer, who is in effect a deputy of the Chief of Ordnance with practically unlimited authority on all Ordnance matters within the expedition;

For each army, an Army Ordnance Officer, charged with supervision of all ordnance activities in the army;

For each corps, a Corps Ordnance Officer, charged with supervision of all ordnance activities in the corps troops;

For each division, a Division Ordnance Officer, charged with supervision of all ordnance activities in the division.

The Chief Ordnance Officer is on the staff of the Commanding General at General Headquarters. He has assistants who operate the ordnance supply and maintenance system in the communications zone and with the General Headquarters reserves.

Each Army Ordnance Officer has a small corps of assistants, among whom are the following charged with maintenance activities:

Artillery Maintenance Officer,
Automotive Maintenance Officer,
Machine Gun and Aircraft Armament Officer.

These men supervise and co-ordinate for the entire army the maintenance of the material with which they are charged, providing shop facilities, furnishing technical information and attending to replacement of personnel. They also take direct charge of the maintenance of material assigned to "Army Troops." They must constantly be inspecting material even to that in the divisions, and for this purpose are provided with one or more assistants.

The Corps Ordnance Officer, according to past practice, is charged only with the material issued to "Corps Troops" and he has no jurisdiction over the activities in the divisions forming the corps. Whether this will be the case in the future organization of our army cannot be stated at the present time. This condition merely means that the activities in the division are supervised directly by the Army Ordnance Officer and not through the medium of the Corps Ordnance Officer.

The Division Ordnance Officer supervises the ordnance activities within his division and is responsible to the division commander for their efficient performance.

Maintenance Activities in Time of Peace

In time of peace maintenance activities are of two kinds. One, the maintenance of material in the hands of troops and the other the maintenance of material in store. The organization for the maintenance of material with troops is based upon the territorial division of the United States into Nine Corps Areas and also the location of our troops in the Philippine, Hawaii and Panama Departments. (See General Order No. 80, War Department, 1919, and General Order No. 21, War Department, 1920.) There is an Ordnance Officer on the staff of each of the above corps area commanders and commanders of foreign departments, whose duties and position are quite analogous to those of the Ordnance Officer of an army operating in the field, and they are charged with the supervision of maintenance of all ordnance material in use in their respective territories. The principal body of mobile troops in each of the above corps area, is or will be a division. The maintenance functions within the division are carried out as previously described in this article, and the Division Ordnance Officer operates under technical supervision by the Corps Ordnance Officer. In those areas which are on the seaboard, there is included the responsibility for the maintenance of coast artillery material. This is handled by the special provision of small shops located in each of the various coast defenses, and by the provision of civilian mechanics as required. In certain of the corps areas there are located the principal training centers for the various branches of the service. These are the Infantry School at Camp Benning, Georgia, the Field Artillery School at Fort Sill, Oklahoma, the Tank Corps Training Center at Camp Meade, Maryland, and the Coast Artillery Training Center at Fort Monroe, Virginia. The importance of these training centers is such that special provisions are made for the maintenance of the equipment used. At Camp Lewis, Washington (Ninth Corps Area), and at Camp Jackson, South Carolina (Fourth Corps Area), there are brigades of motorized 6-inch guns and 8-inch howitzers which are in the nature of "Army Troops." With each of these two brigades there is provided an Ordnance Heavy Maintenance Company. At Camp Eustis (Fort Monroe), there is a brigade of railway artillery to which three ordnance light maintenance companies may be assigned. A railway machine shop is already provided. The Ordnance Officers and maintenance facilities at these training centers as well as those at the Coast Defenses mentioned above and all other Ordnance personnel and facilities on duty with line troops operate under technical supervision by their respective Corps Ordnance Officers.

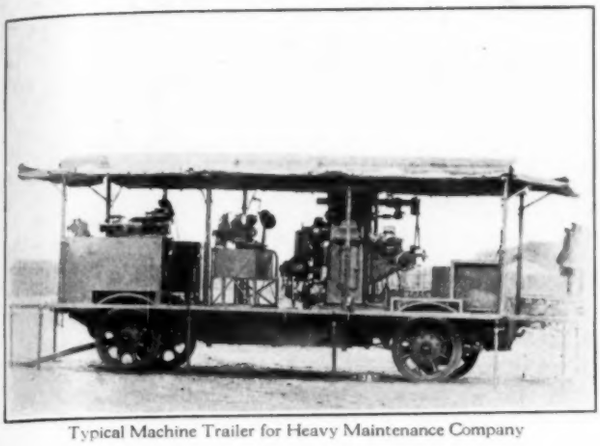
The maintenance facilities in the way of equipment so far referred to are only those in the immediate possession of the Ordnance personnel with troops and thus parallel the equipment with the army. This provision is sufficient to take care of only minor and medium repairs. For the heavier work use is made of permanent ordnance establishments such as arsenals located at various points throughout the United States. One such arsenal is designated to serve each of the various corps area and corresponds to the "Advance Base Shop." In some cases a single arsenal serves several corps areas. These arsenals are operated by the Field Service and combine the functions of a supply depot with those of a machine shop. These arsenals in turn are backed up by the big manufacturing arsenals which serve the purpose of "Base Shops." The Field Service Arsenals used for maintenance purposes are at Benicia, California; San Antonio, Texas; Augusta, Georgia; Raritan, New Jersey; Manila, Hawaii, and Panama and are equipped to make any ordinary repairs. They are our advance base shops and are used for the general repair work in their vicinities. The larger arsenals and the class of work which they perform are Rock Island Arsenal for artillery, tanks, tractors and small arms; Watertown Arsenal for railway artillery carriages and coast artillery carriages; Watervliet Arsenal for guns of all calibers; Springfield for rifles, pistols, machine guns and automatic rifles. These latter manufacturing arsenals do not form a part of Ordnance Field Service, and so at this point in the scheme for maintenance, the work is performed for Field Service by the Ordnance Manufacturing Service in its plants.

The organization for maintenance of material in store is small and direct. All ordnance establishments at which ordnance supplies are stored are supervised by and are directly responsible to the War Department in Washington, and are exempt from the jurisdiction of any local commanders, except for disciplinary and similar purposes. Under this scheme the Field Service operates large storage depots, not only at its own arsenals but also at some of the arsenals belonging to the manufacturing service. Maintenance is accomplished by use of the facilities at the various arsenals and depots, and in general by the use of civilian employees rather than enlisted personnel.

General Overhaul Following the War

There are many functions which the Ordnance Field Service must perform which are somewhat out of the usual and not included in the scheme as laid down above. An unusual example was the work in connection with the reconditioning of material after the war.

Due to the hard use received by Ordnance material in France, to damage incurred in shipment to France and back to the United States, to deterioration from storage in the open, both in France and in the United States, and due also to the condition under which material was manufactured, packed, and otherwise prepared for shipment, we found ourselves after the War with probably 75 per cent of our equipment in such condition that it was unfit for issue to troops, and that if put in storage it would have become entirely worthless within a short time. In order to put the material in proper condition for storage and



Typical Machine Trailer for Heavy Maintenance Company

Ordnance Heavy Maintenance Company in the Field

issue, the first step was a general overhaul by the base shops at Mehun, France, of artillery, small arms, etc., shipped back to the United States. Much of this material, however, suffered so much in shipment that the operation had to be repeated in America. In the case of the rifles it was necessary to put into operation many establishments to be able to complete this work in time to prevent the loss of many of the weapons. Several of the arsenals were employed on work which involved a complete reconstruction of the rifle. A great many similar establishments were used for the lesser operations. Rock Island Arsenal performed an enormous work in overhauling artillery material, tanks and tractors. A special shop was organized at Camp Meade, Maryland, for the rebuilding of tanks, and the establishments at Erie Proving Ground and Savanna Proving Ground were used for the overhaul of both artillery and tractors. The extent of this work, involving the expenditure of many millions of dollars, was equivalent to the normal activities of the Maintenance Division over a period of several years.

Trained Personnel Requirements

Almost all of the work referred to in this article is of a special nature for which there is little opportunity to train in civil life. The necessity of maintaining in time of peace a generous nucleus of trained personnel is obvious. Also the desirability of having a considerable reserve of officers and enlisted men who may be schooled in this work from time to time is apparent. With these to start with in the event of an emergency, and by selecting from the draft men with suitable qualifications, a well trained maintenance force may be developed with fair rapidity; and the fighting troops need not suffer for want of serviceable weapons.

The Office of the Chief of Field Service controls directly all matters connected with its finances, facilities, and military and civilian personnel. The financial operations of Field Service are important and their scope quite extended and involve the control and expenditure of large sums for the necessary overhaul, repair and maintenance of all ordnance material both in storage and in the hands of troops. Funds appropriated by the Congress for Field Service work are allocated directly to the Office of the Chief of Field Service and controlled, allotted and expended under his direct supervision. To convey some idea of the magnitude of Field Service operations, it may be stated that during the past fiscal year, the funds controlled, allotted and expended directly by the Chief of Field Service for its activities totaled in round numbers $30,000,000. The funds available for Field Service activities during the current fiscal year, including approved projects from funds heretofore allocated for specific purposes, total slightly in excess of $15,000,000. It is perhaps illuminating and of interest to mention that the value of present Field Service depots is roughly $83,000,000, while the value of stores for which Field Service is responsible is nearly two billion dollars.

The duties of the Facilities Section, Office Chief of Field Service, are generally as follows:

1. Providing necessary storage space:

(*a*) Securing funds and authority, making layouts and securing construction of additional storage required.

(*b*) Disposing of storage become surplus.

(*c*) Making recommendation as to permanency of storage and policy as far as plant itself is concerned.

2. Providing all necessary equipment and facilities for the operation of the plant.

3. Securing, allocating and allotting funds for maintenance of plant and facilities.

(a) Complete responsibility for the portion of the appropriation "Repairs of Arsenals" allocated to Field Service.

4. All matters pertaining to land, that is, leases, purchases, licenses, etc.

5. Control over distribution and declaration of surplus on plant facilities material.

To properly perform its various function, Field Service requires an absolute minimum at least one-third of the entire authorized commissioned personnel of the Ordnance Department, while the entire enlisted personnel allocated to the Department, except Proving Ground and Training Companies, should be organized, trained and controlled by Field Service as either Ammunition Companies, Depot Companies, or Light and Heavy Maintenance Companies, organizations which have been provisionally approved by the General Staff.

Proposed Form of Standardized Government War Contract

Discussion by Manufacturers and Government Officials

[The publication of Maj. P. A. Galleher's article on "The Standardization of War Contracts," in the November-December number of ARMY ORDNANCE has opened a field of discussion in which members of the Army Ordnance Association are taking great interest, as is evident from the constructive criticism of his proposals printed below.
The original article and discussion thereof are being held in type, and will be reprinted *in toto* as soon as all interested parties have been afforded opportunity to present their views on this important subject. *Further discussion is accordingly invited.*
Ultimately, it is intended to place the entire question before a special committee of the Association, charged with determining insofar as possible the proper policy to be pursued in ameliorating existing conditions, including such recommendations for legislative enactment as may be necessary to attain this end.—ED.]

A. M. Mattice
Advisory Engineer, Remington Arms Co., Inc.

IN his very interesting article on "Standardization of War Contracts," in the November-December issue of ARMY ORDNANCE, Maj. P. A. Galleher very truly remarked that it was a question which must take into consideration the Federal statutes affecting public contracts. In discussing Major Galleher's article I will assume that in preparation for the next war such legislative action will be taken as may be necessary to provide for the making of workable contracts, equally fair to the Government and to the contractor, while at the same time promoting speed and efficiency in performance; and always with a view to restoring to normal, at the conclusion of the war, the business conditions upon which the prosperity of the country depends. Such suggestions as I will make are the result of several years' experience in forming and phrasing and working under war contracts. They are made on my own responsibility.

An old definition of what a contract should be is "an agreement between a party willing to sell and a party willing to buy, conserving the interests of and equitable to both." A brief examination of almost any Government contract will show that it is not equitable to both parties in at least one particular: That it provides in effect that the Government shall be the judge, jury, prosecuting attorney and court of last resort in all matters pertaining to the contract. It requires the contractor to do what he would not think of doing in a contract between civilians; leave everything to the decision of the other party to the contract. It is quite certain that many manufacturers who entered into Government contracts during the late war would, as the result of experience, refuse to sign similar contracts again, but would insist upon more equitable provisions for settling differences. In Major Galleher's proposed form of fixed-price contract he goes even farther than usual in making the Government the sole arbiter; providing that in a considerable number of important details the decision of the Contracting Officer shall be final. A footnote, however, explains that these and certain other innovations are offered only as a basis for discussion.

A serious fault in many contracts is caused by the desire of the draftsman to make the contract terms as short as possible, without going into what appear to him to be unimportant details. Contracts so made may satisfy every requirement of legality, but at the same time be unworkable by reason of the omission of a few explanatory words, and so cause no end of trouble. As an example of this I would mention the matter of "Deliveries," in which Major Galleher's proposed draft follows the usual scheme of Government contracts in providing a schedule of dates and quantities for deliveries, but without defining what constitutes "delivery." In the case of articles which are manufactured and then turned over to the Government inspector for inspection and test, there can be but one kind of "delivery" as regards delivery date, *viz*: "presentation for inspection," for the reason that thereafter the articles are under the sole control of the inspector, and the contractor cannot be responsible for elapsed time, although he is responsible for shipping the articles after the inspector has accepted them, and after shipping instructions have been furnished, and cars are available.

For the above reasons the contract should provide clearly for the various steps connected with delivery, *viz*: delivery proper, as regards schedule dates, which is presentation for inspection; acceptance by inspector and completion of packing by contractor, at which time payment becomes due; and subsequent shipment. Numerous cases can be cited where the contractor has been put to unnecessary trouble and expense by reason of Government officials interpreting "delivery" to mean "shipment." One typical example was that of a quantity of Krag cartridges which the contractor presented for inspection within the period which the contract specified for "delivery." At that time the Ordnance Inspector was overworked with the inspection and test of .30 Caliber Cartridges, Model 1906, which were given precedence, and the Krags put aside to be worked in as opportunity offered. Then after acceptance there was considerable delay in shipment of the Krag cartridges, due to the 1906 cartridges being given precedence as to available cars. From payments due the contractor the Government deducted a considerable amount as liquidated damages for delay, although the contractor had performed his part of the delivery within the allotted time.

Numerous requests on the part of the same contractor to define "delivery" in later contracts produced no result until a short time before the Armistice, when Capt. T. S. Schultz of the Legal Section, Procurement Division, drafted some contracts in which the matters of delivery, acceptance and shipment were segregated and clearly defined in a very few words. If the same few words had appeared in earlier contracts they would have saved reams of correspondence and the time of Government officials and contractors, which time could have been utilized to better advantage otherwise.

I will now comment on a few specific items in Major Galleher's proposed draft of contract, referring to the items by his marginal captions:

Patents. Contract puts the responsibility of *all* patents on the contractor. Should differentiate between patents the use of which is initiated by the contractor and those specified or required by the Government. Such differentiation was provided for in some of the contracts drafted late in 1918.

Precautions. The contractor should be reimbursed for the cost of additional plant protection ordered by the Government and not included in the contractor's estimates.

Sub-Contracts. This is a big subject and cannot be dismissed with three lines. Should be elaborated to avoid the

endless troubles which have been caused by termination of contract.

Payments. The provision that the Government will pay the contractor for the articles "as and when delivered" is a pleasant fiction which will be appreciated by contractors who have had payments held up for long periods. A provision that the Government will pay interest on payments delayed beyond a certain time, as in commercial transactions, should be added. There might be, on the other hand, a provision for a cash discount for payment within usual commercial limits, although it is doubtful if the Government would ever make a payment with sufficient promptness to take advantage of a cash discount.

Adjustment for fluctuations in material costs. Should state the point where the purchase price is figured; *i. e.*, point of origin, contractor's works, or elsewhere, as has been done in previous contracts. The provision that the contractor shall not purchase materials without the approval of the Contracting Officer is impracticable unless provision be made for practically instantaneous approval or disapproval by a Government representative on the spot. Numerous instances can be cited where under similar clauses in cost-plus contracts approval of purchases was delayed for weeks and months, and production would have been greatly delayed except for the contractor taking the chance of purchasing material without waiting for approval. Other cost-plus contracts which omitted previous approval, but provided that the contractor should not pay higher than current market prices, worked out all right.

Adjustment for changes in labor costs. Provides for reimbursement only when higher wages are the result of Government settling labor disputes. This is only a small part of the necessary increases in wages which are beyond the contractor's control and the extent of which could not be foreseen when making his estimates. For instance, the Government arranges for a large cost-plus contract with another contractor in the vicinity, which has to be carried on at top speed regardless of cost, thereby increasing the local rate of wages. The fixed-price contractor must meet that rate or stop production. Such and numerous other contingencies beyond the contractor's control should be provided for.

Material and labor costs are by no means the only costs for changes in which provision should be made in order to make a fixed-price wartime contract equitable. For instance, the contractor takes the existing tax rates into consideration in making his estimates. The Government can easily wipe out his whole profit and more by an increase in taxes. It would be an easy matter to state in the contract what taxes are included in the estimates, and provide for an increase in price to cover later increases in taxes.

Termination. This should be treated as one of the most important clauses in a war contract, and should cover many details in order to prevent later trouble to Government and contractor. There never has been a war which ended on a long pre-determined date, and probably never will be. Wars either end by a surrender or an armistice, with very little preliminary warning. Many contracts will be in full blast when the end comes; with quantities of material in process, on hand ready for processing and obligated for. Consequently the contract should provide for termination as something is bound to come, and not as a remote possibility only. Some of the later war contracts contained fairly elaborate termination clauses, based more or less on the one contained in Supply Circular No. 88, but even those clauses were far from perfect. If the settlement clauses had been more carefully drafted, so that settlements could have been made more promptly, money due the contractors could have been used to pay the contractors' debts, and in turn the debts of their creditors, and so on; thus preventing many financial hardships which followed the Armistice.

As an instance of how a few words added to a termination clause could prevent a lot of trouble, I would cite the absence of provision for partial payments after termination. Contractors were left with great stocks of material on hand which the termination clauses provided that the Government would pay for. The details of settlement for the greater part of the material were arrived at without much difficulty, but there were commitments to sub-contractors which took a considerable time to settle, arranging for salvage, etc. The prime contractors naturally supposed that as fast as details were agreed upon they would receive payment, but to their amazement they found that the Government could not make partial payments on any terminated contract until the last small item had been adjusted. There was, however, one alternative, which was that by signing a certain supplemental contract whereby the contractor agreed to forego certain profits provided by the termination clause in his main contract, partial payments would be made. I would cite the case of one manufacturer who had payments amounting to nearly a million dollars due him under the termination clauses in his fixed-price contracts, but on account of having to wait until the Government had agreed upon the last small details he did not receive a cent until more than fourteen months after the Armistice. A dozen or so words added to the termination clause could have prevented this injustice.

Labor disputes. This clause in the proposed form of contract is practically the same as appeared in a form for fixed-price contracts in 1917, and which, as those familiar with labor disputes foresaw, served to unsettle matters as much as if an engraved invitation so to do had been distributed throughout the contractor's district. Labor had all to gain and nothing to lose by asserting large demands against a contractor whose contract required him to submit all disputes to the Secretary of War and bound him to abide by the latter's decision, for labor was left free to acquiesce or refuse as it chose. After unfortunate experience it was found expedient in the case of certain manufacturers to make provision therefor otherwise than in the contracts themselves. This invitation for trouble was then omitted, but a similar clause was later made mandatory for all contracts by Supply Circular No. 88.

Definitions. The definitions of "Chief of Ordnance" and "Contracting Officer" as used in the contract are practically the same as the much-abused definitions which appeared in various wartime contracts. Their "duly authorized representatives" turned out to be anybody from the office boy up in some cases, but in other cases it was difficult to find a representative who was "duly authorized" to give the necessary attention to any specific matter. It would be easy to provide individual representatives of the Chief of Ordnance and of the Contracting Officer with printed or written instructions defining and limiting their specific duties, authority and responsibility, with copies of the same to the contractors with whom they had dealings; and providing for such credentials in the contract.

I have mentioned only a few of the many details which if included in the late war contracts would have eliminated no end of subsequent trouble, and possibly would have enabled the Government to have settled all contracts before now. A full recital of the many items, which if taken care of in contracts, would make them much more workable, together with the reasons therefor, would require much more space

than would be reasonable for the present discussion; in fact, a fairly good-sized book would be needed to do the subject justice. I happen to be familiar with a number of cases where drafts of contracts were returned by a contractor with suggestions for changes and additions, which modifications the Government refused to make on the ground that they were minor details which could better be left to be worked out later if the necessity arose; but which subsequent events proved would have prevented long and expensive controversies.

The necessity of revision of forms of Government contracts in readiness for the next year, by co-operation between manufacturers and Government representatives, is stressed in a very able editorial article on page 84 of the September-October, 1920, number of ARMY ORDNANCE, in which the writer summed up the present attitude of manufacturers in regard to Government contracts as *"Never again."* He added, however, *"maybe?"* implying that if again called upon the manufacturer would do his bit the same as he did in the World War. But why should the Government expect manufacturers to be sufficiently patriotic to accept one-sided contracts in an emergency? Should not a patriotic Government be fairly considerate of its patriotic citizen manufacturers?

Major Galleher's article opens the way for a much-needed getting together of Government and manufacturers, to work out at leisure forms of contracts which will properly safeguard the interests of both parties, instead of again leaving the matter for a "rush job" after the emergency has arisen. The fixed-price contract, however, notwithstanding the modifications which Major Galleher proposes, is one which must necessarily be very limited in its application in wartime. Notwithstanding the criticisms of the cost-plus form of contract which have appeared in some quarters, properly safeguarded cost-plus contracts must necessarily be the means by which the Government will procure the greater portion of its supplies in the next war, or else we will lose the war.

W. S. Peirce
Assistant Chief of Ordnance, U. S. A.

Major Galleher's article in the last number of ARMY ORDNANCE on the "Standardization of War Contracts" has directed attention to a most important subject. How important it is becomes evident from even the most casual reflection. In time of war the expenditure of Government funds enormously increases, and, excepting the salaries of Government officials and the pay of the Army and Navy, practically all of the huge expenditure is made under contracts of one form or another. Also nearly every industrial organization has to contribute its product directly or indirectly to the execution of war contracts. There is, consequently, very little business done that is not connected with and dependent upon a Government contract.

The written contract is, therefore, really the Constitution under which business will be done in time of war. It defines the manner in which the work required by the Government is to be performed, the conditions which the contractor must fulfill, and the amount and methods of payment. The importance therefore of having these requirements and conditions such that, first, the Government shall obtain the needed articles as promptly and as economically as possible, and, second, that the contractor in rendering his service shall be subjected to no unnecessary hardship, can hardly be overestimated.

In attempting to solve this problem we have nothing except the experience of the last war to guide us. Ordinary peace conditions afford no assistance. There is time then for the contractor to estimate the cost of the work desired under conditions of reasonable stability of prices, opportunity to obtain the labor and materials needed, and in short, to handle the performance of a Government contract in essentially the same way that he does a private contract. Also there is generally the element of competition and an entire freedom of choice as to whether he will attempt the work or not. In war there is practically no competition and little if any choice. The mere possession of an organization, whether accompanied by a plant or not, will impose on him the responsibility of undertaking whatever work the Government may allot to him.

In this connection there is one consideration which I think should be accepted as an underlying principle in the attempt to determine the basis upon which the Government should do business with an industrial organization in time of war. It is that an important element of the compensation the contractor receives is the opportunity afforded by Government business to carry his organization, reasonably intact, through a period in which he would not otherwise be able to employ them, and thus be in a much better position to resume his ordinary business when peace returns. He should not look for nor be allowed, in addition to that, even his normal peace time profit, much less a greater profit. His work is really a service due from him in the national emergency, not a business transaction in which he is free to consider only his own interests.

If therefore we approach the problem of determining the best forms of war contracts upon the basis of the two following principles I believe that the question will be much more clearly defined and the solution easier. These principles are:

1st. The work to be performed is a service rendered by the contractor for which his compensation shall not include the usual amount of profit.

2d. In the performance of his contract the contractor shall be subjected to the least amount of inconvenience possible.

In the paragraph above I spoke of the "best forms" of contracts, because it seems evident that there must be more than one form of contract to fit the great variety of condifions. The forms that readily suggest themselves are the fixed price contract, some variety of the cost plus form, and the agency contract. For each of these general classes it should be possible to evolve one standard form which would serve the great majority of cases. Probably there will always occur instances in which special contracts would be necessary.

There are many points that must be suitably covered in a satisfactory form of written contract. A number of these were described in Major Galleher's article mentioned above. There are several, however, which I think deserve special consideration and study in the light either of their omission or their unsatisfactory statement in the contracts that were negotiated during the war. Among these there are two which seem to me to be of outstanding importance. These are:

(a) The terms and conditions of payment;

(b) The conditions of termination before completion.

With regard to the importance of the first I think no argument is needed to convince any of the war contractors. The terms should be such that, while properly safe-guarding the Government, the contractor should be saved from the worry and expense of financing the work by his own efforts, in excess of his working capital. I have a very vivid recollection of the great number of cases, particularly

in the first eight months of the war, in which contractors having exhausted not only their working capital but their banking credit, did not know from what source they could meet their next pay roll. Sometimes money was properly due them under their contracts, but the machinery of payment was too slow; in other cases they had not yet reached the stage of production which entitled them to payments as their contracts were written.

It must, out of our war experience and ordinary business knowledge, be possible to devise a method of payment which will prevent such conditions.

With regard to the termination clauses used during the war we have now a wide actual experience as to their operation which should enable us to improve them greatly. It seems to have been rather vaguely recognized that an abrupt and complete termination of a contract would produce an unjust industrial situation. What the effect of a country-wide termination would be was hardly visualized by any one. In the individual contract it was apparently sought to mitigate the effect of termination by allowing generally the contractor to complete the articles actually in progress. The opportunity thus to continue work on a supposedly decreasing scale for thirty days or so was the only protection afforded the contractor's employees. The result was that after the armistice there was, in almost all cases, a continuation of production of things no longer needed and a delay in getting back to peacetime work. There was in the vast majority of cases no economy in completing articles which had no salable value except as junk and of which the supply already on hand exceeded all requirements of a reserve stock. Material badly needed for peace uses was consumed and the cost of that material added to the war debt.

I believe that the termination clause should authorize an absolute cessation of work upon the termination of the war need. The contractor can, and should, be protected in that event by reimbursing him for his firm committments and expenses. It is necessary, however, to go further and give an equitable protection to his workmen, as otherwise the sudden throwing out of work of hundreds of thousands of men and women all over the country would precipitate a serious industrial crisis. Conditions will, of course, vary for different contractors, depending upon the character of the product they are making, as to the quickness with which they can turn from war work to peace work. Generally speaking, those who are furnishing materials such as pig iron, steel in bars or other forms similar to those used for industrial purposes, castings, etc., should be able, with negligible delay, to switch to peace work. Those who are engaged upon the manufacture of essentially war articles will require a longer interval. It is suggested, therefore, that the termination clause in each contract should allow to each employee pay at the rate earned the last week of employment for such number of weeks, not exceeding six, as may be deemed necessary for the character of work involved by the contract. The adoption of this method would require the classification of the different kinds of work and the assignment to each of a proper compensation interval so that uniform treatment would be given in each class. There will probably be a difference of opinion as to whether the maximum period of six weeks is more or less than is necessary, but the principle of the suggestion is that the war work should cease at once and both employers and employees be given a fair interval to adjust themselves to peace time industry. I am uncertain whether the present contracting powers of an executive officer are broad enough to cover the proposed compensation of workmen or not. If not, then, of course, suitable legislation must be sought.

There are several other points which the experience gained in settling claims under war contracts indicates should be covered in the future. A standard system of cost accounting should be established and every contract should include a requirement that the contractor's accounts relating to his government work should be kept in accordance therewith. Such a requirement would tremendously simplify both payments under the contract and the settlement of claims arising from it. There should also, I believe, be a requirement under which the prime contractor must either include in his sub-contracts the same limitations as regards profit and termination as are in the prime contract, or else agree to limit the Government's obligation to him on account of sub-contracts to the amounts that could be allowed him in similar case under the prime contract.

The necessity and justice of this last requirement becomes evident from facts which developed during the settlement of claims after the war. While prime contractors were not allowed anticipated profits in their settlements, it was found that under the laws of many states sub-contractors could claim such profits from the prime contractor and therefore were legally entitled to a more advantageous settlement than the prime contractor.

These observations and suggestions are very general in their nature and are offered chiefly for the purpose of bringing the points before the members of the Association for consideration and discussion. The greater the number who become interested in this problem the better the final solution ought to be. It is a work in which many members of the Army Ordnance Association must be vitally concerned and in which their view points and their assistance are, I believe, indispensable. Discussion in the pages of this magazine can prepare the way to crystallize opinion to a considerable extent. But there will then remain the job of embodying the points agreed upon in written forms, and that can not be done here. I therefore strongly urge the appointment of a committee of the Association to undertake this work while the recollection of war experience is yet vivid. I am sure the Chief of Ordnance would be pleased to assign one or more qualified Ordnance officers to co-operate with such a committee.

The opportunity for a great work is here. If it is not embraced I think that future contractors will have little ground upon which to criticize the conditions of their contracts, for they will have had their day in court.

Robert P. Lamont

President, American Steel Foundries

In the main I think the proposed form of Standardized Government War Contract is very good. It takes care of most of the difficulties we found in making contracts during the strenuous war period. I shall, however, comment on a few points.

Clause 1 *(a)*. One of the great difficulties I found in looking over contracts prepared by our negotiators was a failure to describe properly the article. In many cases the description was so vague that it could mean one of several things radically different in cost and construction—easily leading to serious difficulties in the settlement of the contract. Whether or not a line to the effect that the description should be so complete as to leave no possible doubt as to what was intended would be of any help I do not know. Possibly it can only be covered by careful supervision by higher officers having this point in mind.

Clause 1 *(d)* which provides that the Contractor will save the United States harmless from all demands on account of the adoption of any design or for the use of any patented invention, is a rather sweeping agreement, and

while, generally speaking, it is perhaps unobjectionable, there may be cases in which contractors would insist upon riders modifying this clause; for instance, in the case of a complicated machine where all of the drawings and details were furnished by the government, the contractor might not know and might not be able to determine, except by a very lengthy search, whether or not any patents were involved.

Clause 1 *(h)*, which provides that the Contractor will give work under this contract priority over any other work except work heretofore given priority by the United States, no doubt intends to provide that the work is to be given preference over everything except other government work, in which case it would probably be better to say, "heretofore or *hereafter* given preference or priority by the United States."

Clause 2 (*a*-2). This provides that the "contractor shall not purchase any of the articles listed without the approval of the contracting officers." In war times unless prices are controlled they are apt to fluctuate very rapidly from day to day, and if there is any delay on the part of the government and the contracting officer in approving the purchases there may be a big difference between the price mentioned and the price that could be obtained after approval had been received. This delay might also affect the time in which the contract could be completed. Probably the latter contingency is intended to be covered by the general provision in Clause 2 (*a*-6), which provides that the contractor shall not be considered in default if delays are due to causes beyond his control; if not, it should be provided for.

Clause 3 (*b*) which provides that the Contractor shall, in the event that labor disputes arise affecting the performance of his contract, immediately address a written statement thereof to the Chief of Ordnance for transmission to the Secretary of War with the request that such labor disputes be settled, and shall accept and comply with the terms of any settlement which the Secretary of War may direct, may be objected to by some contractors for the reason that if the government work, for instance, is being carried on in one department only of his plant, such a settlement of labor difficulties might involve his entire plant, and again it might involve the whole basic arrangement between himself and his employees; that is to say, it might convert his plant from what is called an "Open Shop" to a "Closed Shop," and the consequences might be very serious. During the War there were a good many circumstances which led to the belief that the labor unions took advantage of the situation to unionize plants, although it was distinctly understood and agreed upon in advance, I believe, that neither "capital" nor "labor" should take advantage of the War to change the status quo existing prior to the time of our entering into it.

R. D. Coombs

President, R. D. Coombs & Co.

It would seem, as yet, uncertain whether or not a single form of contract would be proper for the activities of the different War Department sub-divisions. However, the writer believes that more uniformity can be obtained than might at first seem practicable. Further the writer would urge an open agreement on the general principles on which all such war work should be based, as being essential to the compilation of the ideal form of contract.

The first principle might be termed that of the most arbitrary authority compatible with reasonable justice.

In the first place it should be accepted that waging war necessarily involves an amount of arbitrary or autocratic authority. War is not the acme of polite business and may not involve undue consideration for the desires or interests of individuals. It is assumed that the country has for good reason delegated large authority to its war-making agencies, specifically to its officers of Army and Navy, therefore it is the duty of such agents of the Government to demand and obtain the maximum assistance to the Government obtainable with substantial justice to the individual citizen.

Reduced to its crudest terms, this principle would justify a competent officer seizing material or property, giving a receipt therefor, referring the former owner to a competent Claims Board, and dismissing the matter from further discussion. With the omission of the receipt and the Claims Board, the above is just about what happened in hundreds of wars since the dawn of history. If the ancient plan usually robbed the individual, the latest plan in vogue just as certainly robbed the state. Again it is pure nonsense to grant apparent authority to an officer while withholding the authority universally given similar position in the work of business.

The second principle is that of equal or at least universal obligation to the state.

It is believed that this theory is somewhat generally accepted, but with a very hazy understanding of what it logically involves. The citizens of the State may, during a war period, be roughly divided into the following classes:

(a) The military forces—the members thereof having been selected by the *other* citizens to serve in combat and at a more or less fixed and more or less inferior rate of wage.

(b) The contractors doing direct Government war work.

(c) Those citizens doing necessary but indirect war work.

(d) Those citizens doing non-essential or unnecessary work.

(e) Those doing no work.

With the exception of class *(a)* it is charged that *as a class* none of the other classes did their proper share of the State's work in the recent emergency. There were many shining exceptions, of course, and no general condemnation of government contractors is intended. If some contractors took great risks and in ultimate fact donated moneys and services to the State, there were others who made unreasonable profits. The point is that neither event should have been possible.

The ideal condition would involve classes *(b)* and *(c)* working for no loss but for little or no profit, class *(d)* taking the usual risks as to profit but restricted as to possible profit, with the alternative of entering war work, and the elimination of class *(e)*.

Therefore referring to contractors on governmental war work it is believed that the State should protect such citizens from an unequal contribution to the State through losses and on the other hand prohibit their acquirement of an unequal reward.

It is doubtful whether any officer recently in contact with war contracts would be unable to specify instances of unfair contracts, that is unfair either to the State or to the contractor. When contractors were, in effect, financed by the State it is difficult to justify the payment by the State of great rewards under such contracts. In actual practice this class of contract is presumably necessary, but in effect the individuals in executive charge are believed usually to have received a more than customary reward as salary whatever the profits of the contract as such. The business risk, it will be noted, was borne by the State.

Despite the hue-and-cry over cost-plus contracts there is very much to be adduced in their favor during a war

period. The chief cause of their objectionable results was improper management and a false though general assumption as to the proper rate of reward.

The insertion of an "upset profit" as limiting the maximum profit is unquestionably equitable and in some recent practice was of service to the State. From the standpoint of the Contractor a *carefully* drawn cost-plus contract results in the "profit" being net-profit except as to salaries of some general officers. Therefore with unusually large expenditures in unusually restricted periods of time the result under some of the recent standard schedules of profit was a large net profit per year—in other words, an unfair reward to particular citizens.

It was not true that all cost-plus contracts were extravagant in performance on the part of the contractor. Where adequate supervision was exercised with more or less arbitrary authority, on the part of the Contracting Officers, the results were fairly comparable with non-war performance *save only as to the labor question*—a matter then beyond the control of either the Contractor or the Contracting Officer.

Referring now to some of the details of a contract form, the writer believes that it is entirely unreasonable and improper to require or expect the Contractor to provide protection to the War Department against espionage, or acts of war of any nature. That is not the Contractor's business while it is the Department's business. Further, the Contractor cannot efficiently perform such work, his employees have no legal standing or military reputation to support them. Some recent experience showed civilian guards to be worse than worthless because they occupied the place of enlisted men who would have been efficient. It is always stupid to lose the advantage of public sentimental support, and such support was given the uniform and refused "imitation soldiers."

If it is desired that the Contractor and the Contracting Officer are to work under a sort of partnership arrangement as to prevention of loss to the Contractor it would seem that the itemized analysis or complete cost estimate should be submitted with the quotation and attached to the contract.

Any provision for an increase in price consequent greater-than-estimated prices for sub-contracts would require considerable supervision over such sub-contracts. Otherwise a premium is placed on low estimating and high performance.

The inclusion of clauses relating to claims for delays is a difficult matter, such clauses look well but usually mean little or at least effect but little. "Causes beyond control" cover a multitude of omissions and commissions and are rarely susceptible of proof. What is desired is performance, and lacking adequate performance by the contractor in question the cure is an ouster of the contractor, not a claim for damages.

Existing laws may deny the employment of convicts, etc., on war work, but the fundamental law of their duty to the State would indicate the entire propriety, under proper safeguards, of the State requiring their service. The compulsory commission of another fault against the State has no connection with punishment for the original fault.

The agency form of contract, while perhaps some protection to the contractor and to third parties furnishing goods on unapproved orders, does not have great merit from the standpoint of the State. The credit for purchases is the credit of the State and this credit should be made equally effective under the ordinary form of contract.

It is most desirable that some safe and readily applied method be developed for the so-called "advance payments." One of the most troublesome features of many war purchases was the difficulty in making partial payments, payments in advance of receipt at some distant point, and true advance payments. In practice the Contractor frequently does not possess sufficient funds to carry the job, while the Government "has the money" but gains no advantage by holding it. If the Contracting Officer can be trusted to purchase properly it would appear that he should also be trusted to make partial advances properly. The need for an efficient method of handling this question would be greatly increased under circumstances involving widespread development of the latent facilities of the small contractor.

Under either a cost-plus manufacturing contract or one in which allowances are made the Contractor for variations in sub-contract prices the situation is the same as though the contract were a cost-plus construction contract, *i. e.*, the Contracting Officer should approve sub-contract purchase orders. Provision for this procedure should be a part of the main contract.

It is suggested that consideration be given to the inclusion of a clause looking toward the calling into military service of the Contractors' employees as such.

One form of contract used daily in commercial business consists in a letter quotation with or without reference to blue prints, and a subsequent letter size (or even less) purchase order. It is understood there is good legal authority for the belief that the simplest contract is about the best contract. Certainly the simple forms of contract have the great merit of general understanding and prompt acceptance. There is a more or less general practice of printing an "acceptance" at the bottom of a purchase order, which coupled with duplicate issue and any desired authorizing clauses or titles would seem to approach the requirement of signature by both parties thereto.

It has been urged that the co-operation or mobilization of small contractor's facilities is a most desirable feature of any systematic Reserve plan. Such co-operation would be immeasurably facilitated by a form of contract and other practices less calculated to scare off the little fellow than many former, not to say present, governmental practices. Thus any reputable business concern can issue a letter inquiry to a dozen small contractors with reasonable certainty of receiving quotations from most of them and with equal certainty that the issuance of a purchase order will end the "negotiations" and start the work. Apart from the simplicity and common usage of this custom such inquiries and orders do not usually depart materially, as to specifications, from recognized first-class practice in the given trade. In other words, the contractor knows from a very short description, with or without a blue-print, just what the purchaser can expect and insist upon receiving. How, otherwise, may it be with a government inquiry? Right or wrong, the little newcomer for government custom looks askance at a formidable contract involving his heirs and hopes of a hereafter, requiring or hinting at unusual or unreasonable specifications, and finally recalls the common belief that governmental paymasters never heard of "—— days net."

Advertising for bids, while reasonable and proper in certain classes of work, is impracticable, unnecessary, and defeats its purpose in certain other classes of work. For example, the advertisement of bids for various machines, if published in a thousand papers, would not receive more replies than about three letters would receive. On the other hand, a dozen letters of inquiry to the small contractors would frequently reach more of them than rather extended advertisement, and be much more likely of reply.

[Further discussion of this subject will appear in later numbers of ARMY ORDNANCE.—ED.]

Ammunition Supply

By

ALEXANDER J. STUART
Member A. O. A.

[As Colonel Stuart, Chief of Ammunition Supply Division of the Ordnance Field Service, points out in the interesting article which follows, "to insure maximum efficiency in the supply of this vital material (ammunition), all Ammunition Trains for the army, corps and division should be manned by Ordnance troops, and Ordnance Ammunition Companies should man all army, corps and division ammunition depots and dumps."
The logic which he uses to maintain his contention is unanswerable. As a corollary to this proposition, it would appear to be equally reasonable to organize all Ordnance troops serving with combat units into Ordnance Battalions. Perhaps, as he bluntly states, "force of circumstances will compel it in the next war."—ED.]

The general term "Ammunition Supply" as used in this article, includes primarily the handling and maintenance of ammunition, from acceptance at factory or loading plant to delivery to consuming combatant units. It also includes, however, the storage of components before loading, where necessary, and the salvage at the front of ammunition left by advancing troops and captured from the enemy. As compared with the insignificant quantities on hand before the war, the huge stocks now available and the enormous requirements of a modern army in action give us an entirely new conception of the ammunition supply problem. In order that the nature of the material may be kept in mind in the discussion which follows, it will be well to set forth at this point the essential characteristics of ammunition which affect its supply. These characteristics may be stated as follows:

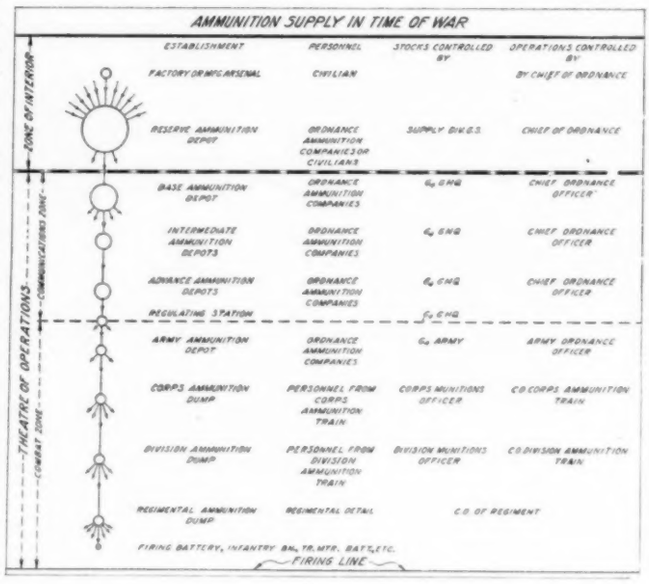


Fig. 1

(a) Hazardous nature, requiring special care in handling and in storage. Rigid precautions must be observed by the personnel and great care must be taken to minimize the effect of an explosion by segregation and special construction of permanent magazines, and, in the case of dumps, by limiting amounts in piles, construction of earth traverses, grouping of types, etc. An ammunition dump is an especially inviting target for hostile artillery, due to the importance of the material and the fact that much of the ammunition will detonate *en masse* if struck by a high explosive shell.

(b) Extreme importance of uninterrupted supply. Not only does the success of an operation depend directly upon the ammunition supply, but in case such supply fails during the operation the result is evidenced at once by an enormous increase in casualties.

(c) Vast quantities required. For example; during the St. Mihiel drive the amount of ammunition to be handled in the dumps of the Toul Sector alone was nearly 10,000 tons per day.

(d) Mistakes in ammunition supply may have extremely serious consequences. The amount of ammunition is usually so limited that in any operation careful allocation to the different units in accordance with the plan of operations is necessary. A mistake in the supply may result in delivery of the wrong ammunition at critical points, which might, in turn, result in the failure of the whole operation. To quote from the report of the officer in direct charge of ammunition dumps of the First Army, A. E. F.: "There can be no mistake in the issuing of orders for ammunition in any park (dump). This rule is definite and any mistake of any kind, whether it is detected before any damage is done or not, is followed by the instant removal of the officer who is responsible. I repeat again, There can be no mistake in the receipt and issue of orders for ammunition. It is fatal."

(e) Complexity, due to large numbers and varieties of projectiles, fuzes, powder charges, etc. This is well illustrated in the "Regulations for Care and Preservation of Ammunition in the Army Area" issued by the First Army, A. E. F., in which the sorting regulations prescribe that unfixed shell, for example, should be sorted by

"*a.* Caliber (including gun or howitzer when necessary);
"*b.* Nature (H. E., shrapnel, chemical, etc.);
"*c.* Filling (kind of H. E., type of shrapnel, nature of chemical);
"*d.* Class (steel, semi-steel, cast iron);
"*e.* Weight;
"*f.* Caliber radius head;
"*g.* Rotating band."

(f) Necessity for keeping lots of ammunition separate, not only for accuracy of fire but so that ammunition which has become unreliable or dangerous through deterioration can be segregated.

(g) Special nature. It is possible to recruit from civil life in time of war men familiar with clothing, subsistence,

telephones, locomotives, and all other material which has a commercial use. For such articles as shell, fuzes, hand grenades, etc., there is no civilian occupation from which men experienced therein can be obtained.

Because of these characteristics, the supply of ammunition is a problem by itself. During the war, not only in our own service, but also in the French and British armies, ammunition was consistently kept entirely separate from all other material.

When, in January, 1919, the office of the Chief of Ordnance was reorganized, in order to take advantage of the experience gained during the war, the Ammunition Supply Division was created with the following functions:

Establishes, organizes, operates, inspects, maintains all ammunition depots and their facilities.
Directs the distribution and supervises the receipt, storage and issue of ammunition.
Is responsible for the maintenance of ammunition.
Organizes, trains and controls Ordnance officers and troops for technical ammunition service.
Establishes and maintains such salvage service as is necessary and consistent with regulations.

The activities for which the Division is responsible may be considered under three general headings, viz: Storage, maintenance and supply proper. A discussion of these activities in time of war will first be taken up, after which the peace time work will be described.

AMMUNITION SUPPLY IN TIME OF WAR

The supply of ammunition in time of war may be better understood by considering it in three phases; in the zone of the interior, in the communications zone or "S. O. S.," as it was called in France, and in the combat zone, which corresponds to what was known in the A. E. F. as the "Army Areas." There is little question but that in a future war ammunition supply would function as in the past from factory to delivery to the armies. However, even the First Army, A. E. F., which had a longer existence and greater experience in active operations than either the Second or Third Armies, did not operate as a unit until the St. Mihiel offensive commencing September 16, 1918, and its ammunition service was never completely divorced from the French, from whom most of the ammunition was obtained. From the varying reports received, it is obvious that the ammunition service of the First Army did not operate long enough to develop a stable plan of supply. Fig. 1 is believed to represent what might be termed the normal flow of ammunition as it existed toward the close of hostilities and probably approximates what will happen in the next war.

Zone of the Interior

Each loading or assembling plant furnishes progress reports giving data as to present and expected future deliveries of completed ammunition. Based on these reports shipping orders are issued by the Ammunition Supply Division covering the shipment of the ammunition, when completed, to a reserve ammunition depot. This depot is a large storage establishment, fully equipped to handle large volumes of all kinds of ammunition, and at which, on the outbreak of war, a certain definite proportion of the total war reserve is in storage. Each reserve depot is manned by Ordnance Ammunition Companies, which furnish personnel, not only for receiving, storing, maintaining and shipping ammunition, but for guarding and fire protection.

The Ordnance Ammunition Company, war strength, consists of six officers and one hundred and sixty-four enlisted men of appropriate grades, organized into one headquarters detachment and four platoons, the platoons being alike. The strength required for any given depot, in addition to certain "overhead" personnel, is made up by the assignment of a sufficient number of companies or platoons. The Ordnance Ammunition Company is a basic organization and is the same whether assigned to reserve, base, intermediate, advance, or army depots, this interchangeability being of obvious advantage. In an emergency these companies will be supplemented by civilians. More detailed information covering these depots will be given later.

Each reserve depot furnishes "reviews" under the Ordnance Provision System, described elsewhere in this issue, and it is upon these reviews that orders for the re-stocking from new production are based, the stocks at each depot being determined in accordance with general instructions furnished by the General Staff as to the plan of operations.

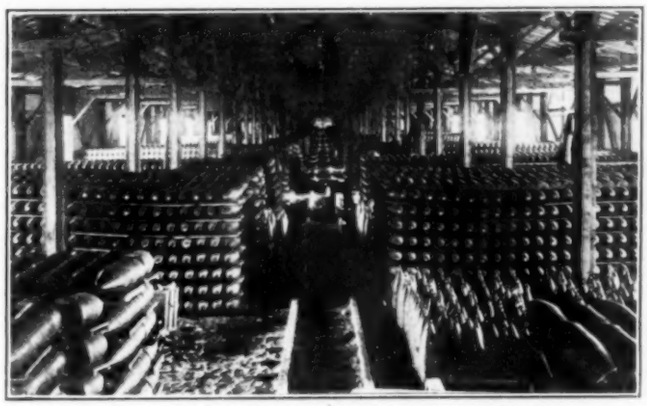


Fig. 2. Type of temporary magazine used in base depot

Communications Zone

Based on demands from the Chief Ordnance Officer of the forces in a theater of operations, ammunition is shipped in large lots on transfer orders issued by the Ammunition Supply Division from the reserve depots to the base depot. This is a large ammunition depot, usually smaller than a reserve depot and essentially temporary in character. Magazines ordinarily of galvanized iron (Fig. 2) are provided so that ammunition can be kept under cover. Railroad spurs, however, are constructed so that all magazines can be filled and emptied directly from cars. The base depot is manned by Ordnance Ammunition Companies entirely if in hostile territory, and possibly supplemented by civilian labor if in friendly territory. The Engineers are charged with the construction of the base depot and all other ammunition depots and dumps in the theater of operations. No attempt is made at camouflage since the base depot is almost invariably far enough from the front to render concealment unnecessary.

If the line of communications is short, shipments of ammunition are made directly from base depot to advance depots on transfer orders issued by the office of the Chief Ordnance Officer. These transfer orders are based on demands made on the Chief Ordnance Officer by the advance depots. The stocks are so adjusted that a sufficient and regular flow to the armies may be maintained. In France endeavor was made to carry thirty days' supply in the base depot and fifteen days' in the advance depot. The latter is similar in general lay-out, types of magazines, rail facili-

ties, etc., to the base depot. An advance depot not provided with magazines is shown in Fig. 3. Personnel for manning advance depots would consist of Ordnance Ammunition Companies.

Should the line of communications be long, as in France, it would be necessary to interpose an intermediate depot between the base and the advance depots in order to absorb fluctuations in the rate of shipment. The intermediate depot, however, would be of the same character as regards personnel, construction and lay-out as the advance depot and its stocks would be regulated and controlled in the same way. The operation of the Ordnance Provision System extends only to the advance depot.

Combat Zone

Between the advance depot and the army is placed the Regulating Officer, who is under G4, G. H. Q., and who has the very important function of seeing that no supplies enter the combat zone faster than they can be handled, thus preventing congestion. Through the hands of the Regulating Officer must pass all demands for supplies, and no supplies can be forwarded from the communications zone until cleared by him.

Fig. 3. General view of advance ammunition depot not provided with magazines

Shipments are made to the next link in the chain, the army ammunition depot, from the advance depot under a different system. In the combat zone the unit of ammunition is the "day of fire," which represents what each gun would consume during one day in vigorous action and is at present fixed as shown below for the smaller guns and howitzers:

75-mm. gun	300 rounds
155-mm. howitzer	150 rounds
155-mm. gun	100 rounds
8-in. howitzer	100 rounds
75-mm. anti-aircraft	30 rounds

G4, G. H. Q., determines the allowance of ammunition in days of fire for all guns in the army for a given period of time and gives the army a credit for this ammunition in the advance depot. Once this credit is granted the ammunition is considered as belonging to the army and is held subject to the order of G4 Army. Shipments are made usually on telegraphic order of G4 to the army ammunition depots (Fig. 4), which are similar in character to the advance depot, though smaller and are ordinarily at the broad gauge railhead. The army depots are manned by Ordnance Ammunition Companies and are operated under the direction of the Army Ordnance Officer. These depots normally contain every kind of ammunition except that for railway artillery of large caliber, which operates directly under G. H. Q. They supply the army artillery (not shown in Fig. 1) and the corps in accordance with allowances determined by the Chief of Artillery of the Army, which are based on the plan of operations. Credits are granted to the corps for ammunition in the army depots, as was explained in the case of the army, and the ammunition is transported to the corps and army artillery dumps by truck trains, narrow gauge railway, or both. If the army has sufficient motor transportation, it is used for this purpose. Otherwise the burden of forwarding the ammunition which cannot be handled by narrow gauge falls on the corps ammunition train. Responsibility for the ammunition supply in the corps rests on the Corps Munitions Officer, who, during the war, was on the staff of the Corps Artillery Commander.

Corps dumps are smaller and less elaborate than army depots and contain fewer types of ammunition. The shell may be simply piled in the open and covered with paulins, but fuzes and powder should always be given better cover. Since the corps dumps are usually well within range of enemy artillery, all movement of ammunition must be carried out at night and the dumps carefully camouflaged. To facilitate issues, incoming ammunition must be sorted and different calibers, types, etc., piled separately. Piles of shell must be separated by traverses of earth or sand and must contain limited quantities. The maximum amount of ammunition which could be placed in one pile was prescribed in regulations issued in France, as follows:

Type and caliber	Number per pile
37-mm.	10,000
75-mm.	6,000
4.7.-in. shell	2,000
155-mm.	1,000
8-in.	500
9.2-in.	400
10-in.	250
12-in.	150
14-in.	100
Powder charges, tons per magazine	20
Fuzes, per hut	10,000
Small arms	50,000

The corps dumps are manned by personnel from the corps ammunition train, which is composed of artillery troops. From the corps dumps the ammunition is supplied to the corps artillery (not shown on chart) and, in turn, to the division dumps, regimental dumps and battery positions, or infantry battalion dumps. In theory, each unit should forward ammunition to the next smaller units in front, but in practice, unless transportation is sufficient, this will not be practicable and it will be necessary for the division, for example, to go back to the corps dumps for its allowances. As we approach the front the dumps of each succeeding lesser unit become smaller and contain fewer types of ammunition, while the necessity for concealment and careful traversing increases. A regimental dump is shown in Fig. 5. This dump, while not camouflaged, was protected from observation and fire by a hill and was used as a re-filling point.

Fundamentally, accumulations of ammunition such as advance depots, army depots, corps and division dumps, etc., serve the following purposes:

(a) Absorb fluctuations in the rate of flow so that a constant and sufficient supply is available to the using unit;

(b) Reduce the length of haul for truck trains so that trains may be better controlled;

(c) Permit the breaking up of bulk shipments, which are necessary in the back areas for volume, into shipments of complete rounds, in which form the ammunition must arrive at the battery.

The best solution for any given situation is the minimum number of dumps or depots which will serve these purposes without congestion.

It should be thoroughly understood that the above represents only the normal conditions and must be modified wherever circumstances require. In the Zone of the Interior one of the reserve depots itself might become a base ammunition depot or even an advance depot, depending upon the location of the theater of operations. In the combat zone it may be advisable and feasible to ship direct from corps dumps to battery positions, or from army depots to division dumps. Then again, it may be necessary for the army to establish advance depots containing only one or two kinds of ammunition in order to avoid congestion and to simplify supply. In general, so far as possible, the scheme of supply should be so arranged that ammunition moves straight to the front and all cross-hauling is avoided. An excellent description of the method used in the A. E. F. for supplying ammunition within the combat zone will be found in the July number of the *Journal of the United States Artillery*, in which appeared an article entitled "Ammunition Service in the A. E. F.," by Col. P. H. Worcester, C. A. C.—well recognized as an able and experienced officer of sound judgment, who served first as Division Ordnance Officer, and later as Army Artillery Ordnance Officer on the Staff of the Chief of Artillery of the First Army.

Fig. 4. An army depot well concealed

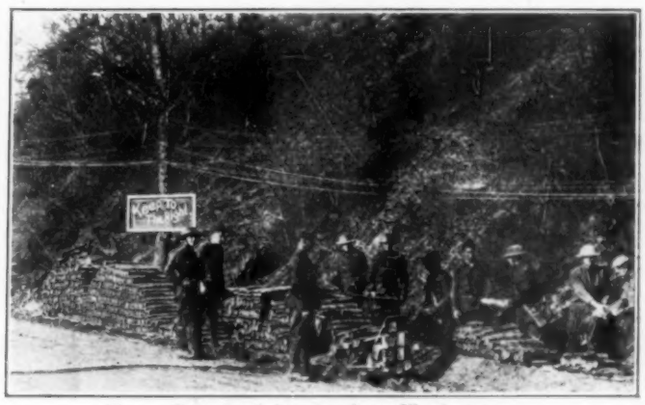


Fig. 5. Regimental dump ready to fill caissons

Salvage of Ammunition

In the case of an advance by our troops, four different classes of salvage activities may become necessary, as follows:

(a) In order to be sure of an adequate supply, there is a tendency in each unit to accumulate as much ammunition as possible in its dumps. When an advance is made much of this ammunition is left behind, and if not taken care of may become a total loss. In France the amounts which were so abandoned at times reached surprising figures due to the lack of close control which resulted from untrained personnel, especially during the early fall of 1918. The salvaging of this ammunition is most desirable, since it can usually be re-issued and relieves the strain on the lines of communication to a corresponding extent.

(b) The stocks in captured ammunition dumps may be utilized by our troops in an emergency if the corresponding enemy guns have also been taken, or if it can be modified to fit our guns. In any event it may be necessary to carefully examine shell piles to detect chemical or other fuzes, such as used by the Germans, designed to blow up the dumps after a given time.

(c) Unexploded shells may be in such condition that only a very slight shock is necessary to cause detonation. Every battlefield is more or less strewn with these "duds," which must be carefully destroyed. A number of lives were lost in France in this work, which was at first performed by untrained personnel.

(d) An unscrupulous enemy may leave behind devices designed to kill or disable our troops, such as foot grenades—which detonate when stepped upon, and bombs and mines in various disguises, the removal and destruction of which is necessary.

For all of these purposes personnel trained in ammunition is obviously required, and during the closing months of the war it was to the Ordnance Department that the troops looked more and more for the proper handling of this work.

AMMUNITION SUPPLY IN TIME OF PEACE

In time of war the distribution or movement of ammunition to the using unit is of primary importance. New storage facilities required are temporary and simple in character and only temporary measures need be taken for the preservation of the ammunition, since it is soon expended. In time of peace the situation is entirely different. The distribution becomes routine and of small proportions, being concerned only with the comparatively small amounts required for target practice. The provision of permanent storage facilities, considering the enormous reserve necessary, and the preparation of ammunition for permanent storage are of first importance. An insight into the question of ammunition supply during peace time can be best obtained by a discussion of the problem which confronted the Ordnance Department on the signing of the armistice in connection with the storage and maintenance of the immense quantity of ammunition on hand and the solution which was worked out.

Storage

In the storage of reserve ammunition it is first necessary

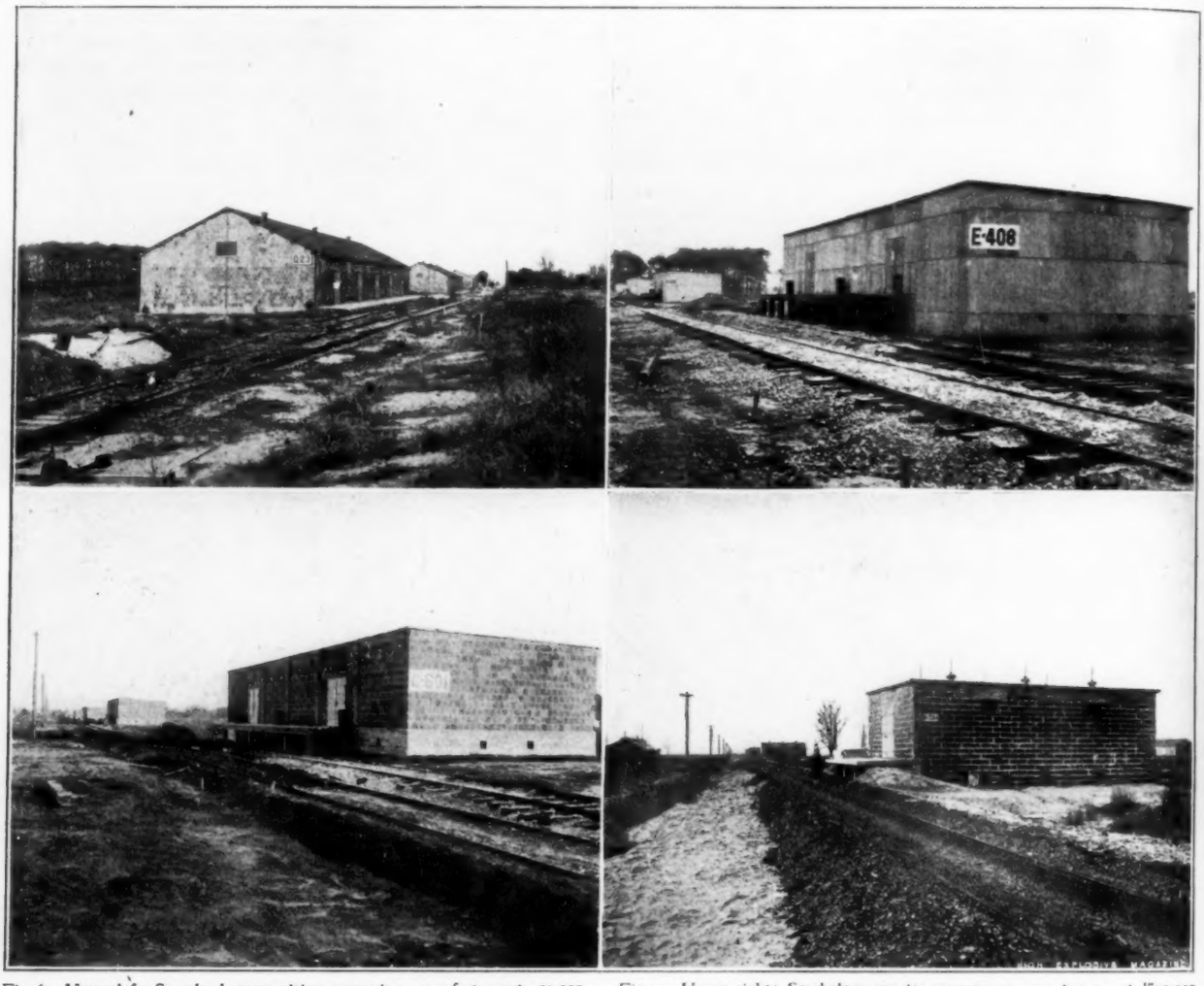


Fig. 6. Upper left: Standard ammunition magazines, 300 feet apart, 50 carloads capacity

Fig. 7. Upper right: Smokeless powder magazines, 300 feet apart, 500,000 pounds capacity

Fig 8. Lower left: Primer and fuse magazines, 300 feet apart, 3,000 square feet floor area

Fig. 9. Lower right: High explosives magazines, 800 feet apart, 250,000 pounds capacity

to determine the proper strategic distribution. Guns, tanks, tractors, and other articles of equipment should be located primarily with reference to the probable mobilization points of the troops to be equipped. Ammunition, on the other hand, should be located only with reference to the probable theaters of operation, since, aside from small amounts for target practice, consumption of ammunition only commences with the beginning of active operations and occurs only in the combat zone. After determining the proper distribution of reserve ammunition it is then necessary to provide facilities at the points selected so that safety and accessibility can be had with a minimum of expense.

When the signing of the armistice suddenly cut off the flow of ammunition overseas, a hurried survey of the situation indicated that the existing ammunition storage facilities would be entirely inadequate to take care of the immense volumes of this material which had been produced and which would be returned from overseas. There were in existence or under construction five depots along the Atlantic Coast intended for the forwarding of ammunition overseas, and which were provided with magazines of a permanent character. These depots were—Raritan Arsenal, near New York City; Delaware General Ordnance Depot, near Wilmington, Del.; Curtis Bay General Ordnance Depot, near Baltimore, Md.; Pig Point General Ordnance Depot, near Norfolk, Va., and Charleston General Ordnance Depot, near Charleston, S. C. In order to remove the immense quantities of ammunition which were accumulating at the factories and loading plants, in the railroad yards and even on board lighters, a number of loading plants were converted into temporary storage depots. As soon as this work was well under way a thorough study of the problem was made to develop a comprehensive ammunition storage policy, while another study was made to determine the total amount of the ammunition on hand which should be retained as a war reserve. As a result of the first study a policy was recommended to, and approved by, the Secretary of War, which contemplated the construction of new storage facilities near Ogden, Utah, and at Savanna Proving Ground, Ill. The approved distribution has been described in a previous number of this Journal, and provided, briefly, for the location of approximately 25 per cent of the reserve, to consist only of finished ammunition, in the five permanent depots already mentioned, 15 per cent also to consist only of loaded ammunition, near Ogden, and the balance at the Savanna Proving Ground. This distribution, while not ideal, provides satisfactory accessibility and safety with a minimum of cost and is believed to be the best which could

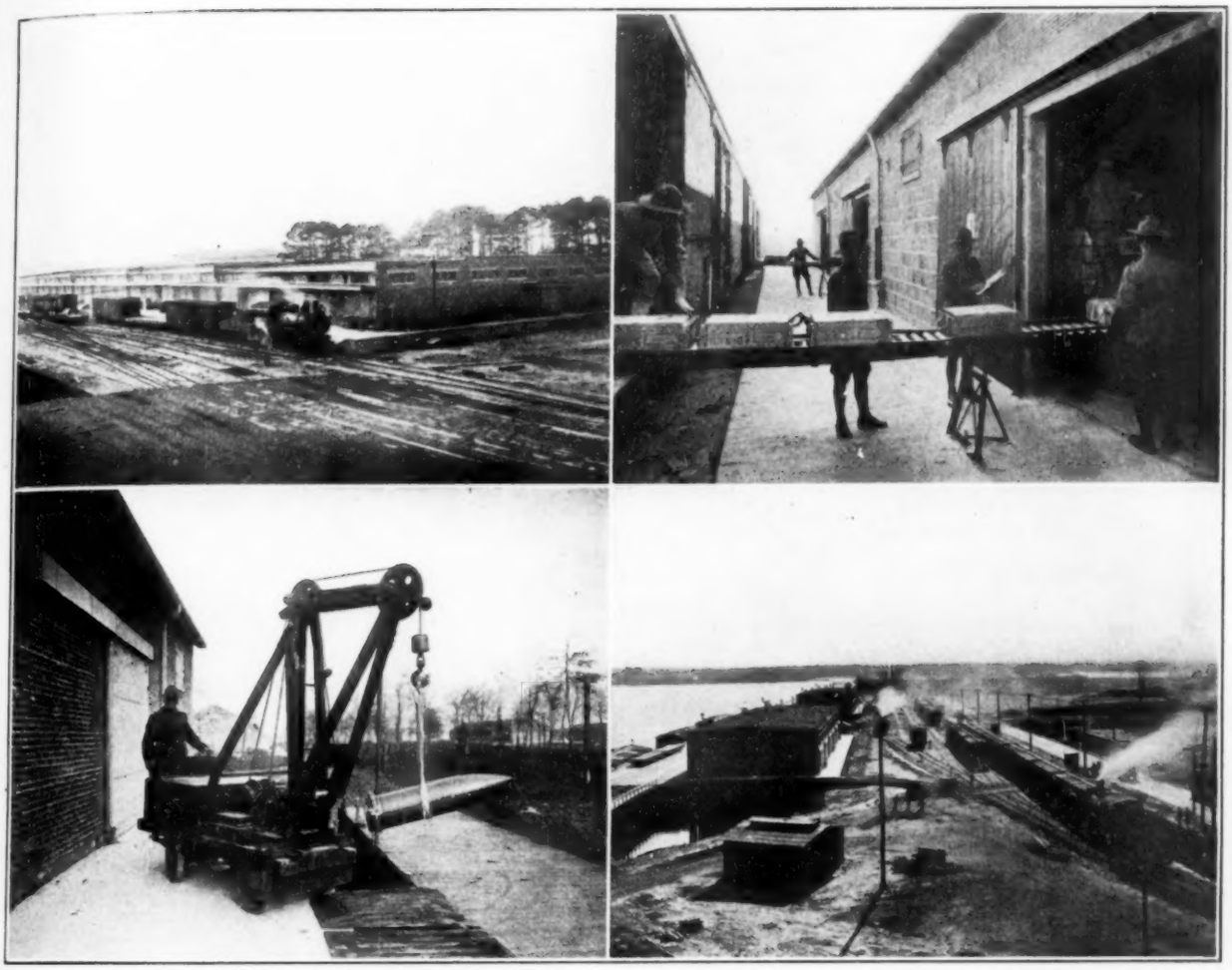


Fig. 10. Upper left: Standard warehouse for inert components, bays 100′x160′
Fig. 11. Upper right: Unloading a car with roller conveyor
Fig. 12. Lower left: Electric portable crane
Fig. 13. Lower right: Dock with dock magazines

be obtained under the existing conditions. At the present time construction work at Savanna and Ogden is under way.

For purposes of supply, ammunition, like all other Ordnance materiel, is classified in accordance with the Ordnance group system. With respect to storage conditions, however, ammunition and components may be divided into six classes, as follows:

1. Finished ammunition and loaded components. This includes complete rounds ready for firing, except separate loading propelling charges.
2. Smokeless powder, including both powder in bulk and in the form of made-up separate loading propelling charges.
3. Fuzes and primers. This class includes all fuzes, primers, loaded boosters and components of similar nature.
4. High explosives. Under this heading are stored black powder and high explosives such as T. N. T., picric acid, explosive "D" and tetryl.
5. Sodium nitrate.
6. Inert components. This class of material consists of empty shell, boosters, metallic components of fuzes, and also small arms ammunition.

Class One. This class is stored in standard ammunition magazines (Fig. 6) approximately 50 by 220 feet, spaced 300 to 400 feet apart. These magazines are of hollow tile construction with concrete floors, having a permissible floor load of at least 1,000 pounds per square foot. On account of the tonnage of ammunition and the weight of an individual shell or package, ammunition magazines are always provided with standard gauge railroad track. The principal characteristics of this class are great weight and moderate sensitiveness. Shell below 6 inches are not subject to mass detonation, and while shell of 6 inches and larger caliber may detonate *en masse,* there is very little likelihood of this except in case of fire. The ammunition magazines present a fire-proof exterior and are so constructed that in the event of an explosion the walls and roof will break up into small fragments so that there is no danger of large masses of debris being thrown any appreciable distance.

Class Two. Smokeless powder magazines (Fig. 7) are approximately 32 by 96 feet, with a capacity of 500,000 pounds and are placed 300 feet apart. They are of lighter construction than the ammunition magazines, having wooden floors, walls of asbestos siding and gypsum slab roofs. Smokeless powder does not explode, but if ignited burns with an extremely intense heat. The spacing of 300 feet and the fire-proof exterior are sufficient to prevent the spread of fire from one magazine to another. The capacity of the magazines is limited only by the necessity for limiting the loss in case of fire.

Class Three. Fuzes and primers are stored in magazines 32 by 96 feet, spaced 300 feet apart (Fig. 8.) These buildings have wooden floors, hollow tile walls and gypsum slab

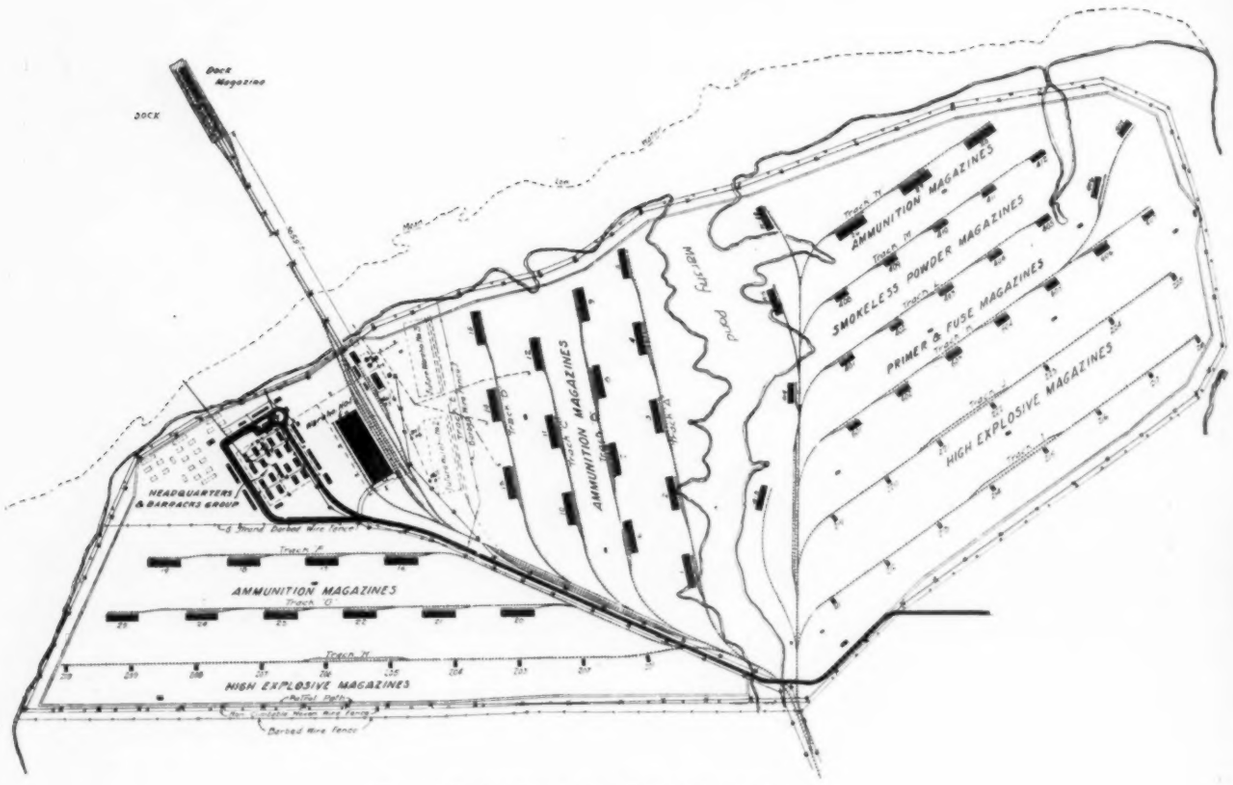


Fig. 14. Typical layout of small reserve ammunition depot

roofs. The distinguishing characteristics of this class of material are great sensitiveness, high cost, and the fact that the destruction of a comparatively small amount in bulk would render useless a relatively large amount of other components. For this reason magazines are comparatively small and the exterior thoroughly protected against sparks or fire.

Class Four. High explosives are stored in magazines about 26 by 42 feet, with hollow tile walls and gypsum slab roofs (Fig. 9.) These units are designed for a capacity of 250,000 pounds of explosive and are spaced 800 feet apart, thus complying with the American Table of Distances. High explosives are comparatively sensitive, and, in case of fire it is very likely that most of the explosive would detonate. The hollow tile gypsum slab construction, therefore, is necessary to prevent damage from very heavy missiles.

Class Five. Sodium nitrate is very soluble in water. It is an oxidizing material rather than an explosive and will not even burn unless mixed with a combustible material. It has a highly corrosive action on exposed metal work. In time it sets to a rock-like mass. Two hundred thousand tons of sodium nitrate are to be stored at Savanna Proving Ground in a concrete trench, the nitrate simply being dumped in, rolled, and then covered with a water-proofing of pitch compound.

Class Six. The standard warehouse for inert material is constructed in sections 100 by 160 feet, with concrete floors, brick walls and wooden roofs (Fig. 10). A brick fire wall is placed between adjoining sections.

The standard method of handling all ammunition except large caliber shell is by roller conveyor, the use of which in unloading a car is shown in Fig. 11. It was also found necessary to provide the electric portable crane shown in Fig. 12 to handle the large shell. In the event of overseas shipments, a typical dock with magazines from which lighters can be loaded is shown in Fig. 13. Lighters are loaded both from cars run out on the dock and from stocks carried in the dock magazines. It is necessary that the latter be provided in order to avoid holding up the lighters. In receiving ammunition from ships the dock magazine performs a similar function.

Fig. 14 shows a typical layout of an ammunition depot, with the various classes of magazines, railroad, spurs, etc.

As previously stated, reserve ammunition depots in time of peace are manned by Ordnance Ammunition Companies, if necessary, by civilians. Due to the fact that men drafted or enlisted for the war had to be discharged soon after the armistice, it became necessary to employ civilian forces to operate the depots. Arrangements have already been made to replace these civilians by Ordnance Ammunition Companies so far as the number of such Companies will permit. The organization of these Companies on a peace basis provides for two officers and eighty-three enlisted men, organized into two platoons, instead of four as in the war organization. These Companies will not only handle the receipt, storage and issue of all ammunition, but will perform the administrative work of the depot, such as checking and following up of requisitions, preparation of reviews, and all other work for which civilians are not absolutely necessary. In this work the operation of Ordnance motor vehicles is necessary to supplement the depot railroad system and to reach magazines not on the railroad. For the proper performance of these duties personnel of the Companies are given thorough instruction in ammunition of all kinds and in the operation, repair and up-keep of the motor transportation used. This instruction, together with the practical work incident to the operation of the depot, will provide a highly trained force capable of operating ammunition depots, dumps and trains in the event of war.

Some idea of the magnitude of the present ammunition storage problem may be gained from the fact that war reserve ammunition will require approximately 172 ammunition magazines, 360 smokeless powder magazines, 229 high explosive magazines and 100 warehouses 100 by 160 feet. These magazines, placed in one line with normal spacing, would extend nearly ninety miles. The total value of the ammunition to be stored, computed by multiplying the number of rounds by the contract price per round, is approximately $1,000,000,000. The amount actually spent, however, by the United States for ammunition was over $2,250,000,000, the difference largely representing increased manufacturing facilities which had to be provided.

Maintenance

Practically all the ammunition on hand was manufactured during the war, with the expectation that it would be fired in a comparatively short time. It was therefore given only such protection as would insure its reaching the firing line in good condition. Furthermore, a considerable portion of the reserve ammunition was not loaded and will be stored in component form. Most of these components were given only sufficient protection to prevent deterioration between factory and loading plant. After a great deal of study, instructions were issued by the office of the Chief of Ordnance covering the steps to be taken in placing this ammunition in condition for permanent storage, and the Secretary of War authorized the expenditure of over $9,000,000 for the work, which was commenced in the spring of 1919, but was suspended in August until more definite information could be obtained as to the total amount of each caliber which would be retained as war reserve. In December of 1919 the work was resumed and is now fully under way.

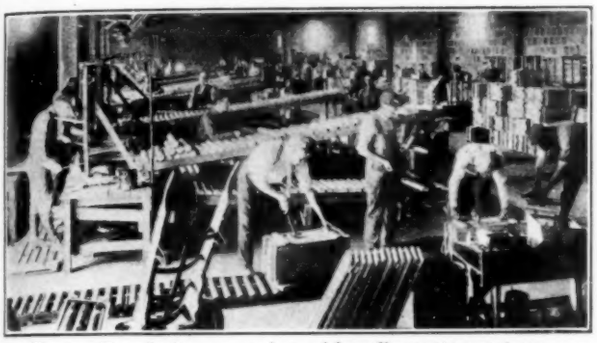


Fig. 15. Transferring 75 mm. shrapnel from fiber to tin containers

The principal operations consist of the painting of empty shell, the transfer of propelling charges from fiber to steel containers, transferring 75-mm. shell and shrapnel to tin containers, and the zinc plating of empty boosters. Before the war the standard method of protecting 75-mm. fixed ammunition was to place each round in a tin cylinder, the lid of which was then soldered on. During the war, due to the shortage of steel, it was necessary to develop a fiber container for this purpose. Much of the 75-mm. ammunition is being transferred to the tin containers. (See Fig. 15.)

For a similar reason it was found necessary to develop a fiber container to replace the steel cartridge storage cases which were ordinarily used for the protection of smokeless powder propelling charges. A new and very efficient type of cartridge storage case was developed toward the end of the war and these containers are being used to replace fiber containers in which the charges were packed. (See Fig. 16.)

Another very important phase of the maintenance of ammunition is the chemical control of explosive components known as "Surveillance." It is well known that smokeless powder is subject to spontaneous decomposition, the probability of which increases with the age of the powder. Certain tests have been developed through which this decomposition may be detected in the early stages. Each lot of powder is kept under constant observation by means of continuous and periodic tests, so that when any lot shows evidence of instability it may be withdrawn from service and re-worked or destroyed. The most elaborate tests are conducted at Picatinny Arsenal, but are supplemented by simpler tests at the point where the powder is in storage. For this reason it is necessary that accurate records be kept of the location of each lot, and when it is remembered that there are over 4,500 lots of powder on hand scattered all over the country and in the island possessions, the magnitude, importance and complexity of the work can be appreciated. At each large ammunition depot a trained "Surveillance Inspector" is stationed, who is responsible for the periodic testing of all powder and explosives at that depot.

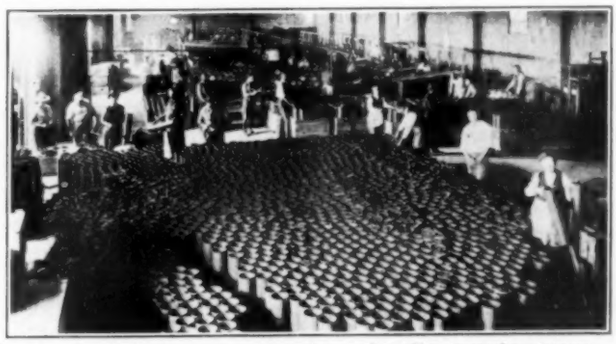


Fig. 16. Transferring 155 mm. powder charges from fiber to steel containers

It is important that not only smokeless powder but practically all ammunition and components be so stored that the lots are kept separate. The reasons are as follows:

(a) To facilitate the prompt withdrawal from service of deteriorated powder.

(b) To permit the supply to troops of any given quantity of ammunition of the smallest possible number of different lots. This is necessary, not only because of the simplification of the problem of withdrawing unstable lots after issue to troops, but because, due to difference in muzzle velocity and consequently in range, it is necessary to adjust the fire for each different lot of powder.

(c) During the war all ammunition was not manufactured exactly according to one uniform set of specifications. Certain departures from the standard had to be allowed some manufacturers, and in many cases it has been found that, due to different inspection methods or other causes, the output of some manufacturers was below standard. It is sometimes necessary to correct defects in all or part of the ammunition produced by a certain manufacturer. By keeping the lots separate the location and identification of lots known or suspected to be faulty is thus facilitated.

(d) It makes it possible to insure that the ammunition of any lot or manufacture which is expected to deteriorate within a short time is consumed first.

Distribution

The scheme of ammunition supply in peace time under existing regulations is shown in Fig. 17. The *expenditure* of ammunition for ordinary purposes can only be approved

by the General Staff, which approval is usually in the form of standard target practice allowances. The *issue* of ammunition, however, is controlled by the Chief of Ordnance, who may establish such local stocks at each station as may in his discretion be advisable to take care of requirements.

In the case of ammunition for permanent Coast Defenses, practically all of the amounts available are stored at the batteries and the functions of the Ordnance Department are limited to replacing target practice ammunition as expended and distributing new service ammunition, as manufactured, to the Coast Defenses in accordance with policies approved by the General Staff. In this connection a scheme has been worked out and approved whereby the powder charges at each battery will be so replaced that ultimately such charges will consist of one lot as far as practicable. The advantages of this "one lot per battery scheme," from the standpoint of accuracy of fire and simplification of surveillance, can be readily understood.

Requisitions are submitted by the Ordnance Officer at each station direct to an arsenal or depot designated by the Chief of Ordnance for the supply of ammunition within authorized allowances. Requisitions for exceptional amounts must be approved by the Corps Area Ordnance Officer. An Ordnance establishment, conveniently located with respect to each Corps Area, has been designated for the supply of ammunition to all stations within the Area. This system has been operating for the past year with entire satisfaction. The function of the Washington office is limited to the transfer from time to time to issuing establishments of ammunition sufficient to enable them to fill requisitions for at least one year. It is only in the case of items of which a very limited supply exists that control over the issues is exercised by the Washington office.

Under the Ordnance Provision System, reviews submitted periodically give the status of all items of ammunition at each Ordnance establishment in the United States. The frequency of these reviews is varied from time to time as conditions demand. In the case of items of which a large supply exists as compared with requirements the reviews are semi-annual; in the case of ammunition of which there is a shortage, monthly reviews are usually required.

Summary

Insofar as the supply of ammunition is concerned, as the result of the war and the studies made since, we have—

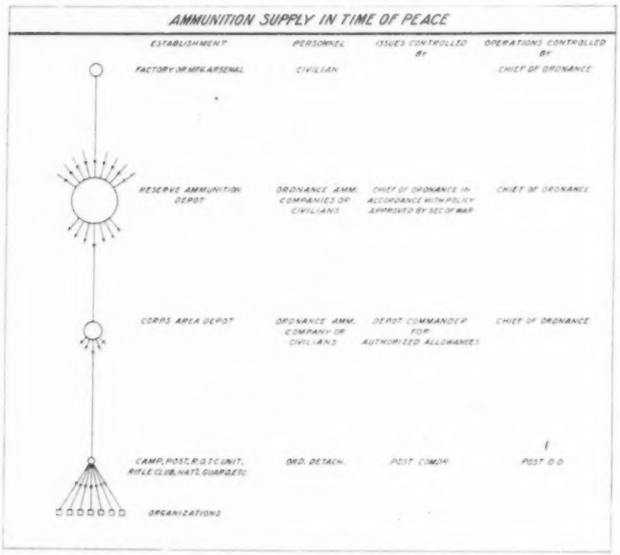


Fig. 17

A knowledge of the enormous requirements of a modern army in action.

A war reserve of ammunition sufficient to meet these requirements until new ammunition can be manufactured.

A policy for the strategic distribution of this ammunition approved by Congress, which has already provided part of the funds necessary for carrying the policy into effect.

A tested supply system for the forwarding of this ammunition from factory to the combat zone.

A nucleus of personnel trained in ammunition, capable of rapid expansion in time of war.

The only feature of the present situation which is considered unsatisfactory is the scheme of supply within the army, particularly the manning of ammunition trains and ammunition dumps forward of the army ammunition depots by Artillery troops.

It is a fundamental principle of army organization that the business of the combat troops, Infantry, Cavalry, Artillery, etc., is to fight and that the full attention and strength of these troops should be concentrated on this purpose. No supply problems should be allowed to divert the attention and energies of these troops if it can possibly be avoided.

The company, battalion, regiment and brigade are homogeneous units, being composed of troops of one arm. It is recognized that it would be undesirable for a number of reasons to introduce an organization of another arm in the brigade, regiment or battalion, even to relieve them of supply work. However, when we come to the division, the smallest organization which is composed of all arms and is capable of operating alone, the situation is entirely different. In this case organizations of Quartermaster troops are provided for the supply of rations, clothing and other Quartermaster material, and Ordnance troops for the supply and up-keep of guns, small arms, spare parts, etc. No one has ever suggested that the supply of food, clothing, etc., in the division should not be handled by Quartermaster organizations, but, in the case of ammunition, which requires much more highly trained personnel, the supply is turned over to the Artillery, in violation of the principle stated above, apparently for the reason that the supply of ammunition to the 75's is much more important than the supply of small arms and 37-mm. ammunition, grenades, flares, rockets, etc., is to the Infantry. That the Infantry, "The Queen of Battles," upon whom the final success of any engagement depends, is not entirely satisfied with this arrangement has been repeatedly demonstrated in the past war.

In the article by Colonel Worcester on "Ammunition Service in the A. E. F.," above referred to, the author states:

"In addition to the changes brought about by shortage of rolling transportation and the establishment of recognized corps dumps, a decided change of opinion came about in many divisions as to the suitability of having the artillery handle the ammunition service. In many units, where G1 was functioning smoothly, this service was transferred from the artillery to G1, thereby relieving the busy Artillery commander of a very troublesome supply function, giving him time for tactical duties which were very heavy, and placing the ammunition service under the control of the officer responsible for other services. This change was not officially recognized at any time in the A. E. F. and the Staff School at Langres continued to teach that the am-

munition service was an artillery function," and, again, on page 47, occurs the following:

"I have heard the following three solutions suggested for the proper designation of the Division Munition Officer in tables of organization:

(a) On staff of the Artillery Brigade Commander;

(b) A Service under G1;

(c) A duty of the Division Ordnance Officer, giving to that officer a commissioned assistant.

It is my opinion that it is decidedly a G1 function rather than an artillery function; and since ammunition manufacture and supply is an Ordnance matter I am convinced that the Ordnance service, both in Army, Corps and Division, should handle ammunition service."

There is probably no officer who had a better opportunity to observe the working of the American ammunition supply system in France and who is in a better position to pass judgment on the shortcomings of that system. His views are therefore entitled to most careful consideration. As a general proposition, it is believed that any branch of the service can perform any function—given personnel, time and training facilities necessary, but when it is remembered that the immense reserve ammunition depots will be manned during peace time by Ordnance Ammunition Companies, who must, from the very nature of their duties, become thoroughly trained in ammunition and who will have had experience in transportation by motor truck, it would seem only logical in time of war to expand these troops sufficiently to handle all ammunition supply, from the factory to the division dumps, thus permitting the Artillery to give its entire attention to fighting.

Specifically, to insure maximum efficiency in the supply of this vital material, all ammunition trains for the army, corps and division should be manned by Ordnance troops and Ordnance Ammunition Companies should man all army, corps and division ammunition depot and dumps. Whether or not this assignment of duties is incorporated in the reorganization of the Army now under way, force of circumstances will compel it in the next war.

Discussion

Philip H. Worcester

[Colonel Worcester was, during the World War, successively Ordnance Officer of the 82d Division; Ordnance Officer, First Army Artillery; and Commanding Officer, 146th Regiment of Field Artillery. This well rounded experience under conditions of active service qualifies him to speak from an unusually well-informed viewpoint on the vital question of ammunition supply in time of war.—ED.]

I have read Colonel Stuart's article on "Ammunition Supply" with the greatest interest. It appears to me that he has covered the subject very thoroughly.

In the World War our army organization was patterned after that of the French, to a great extent. As we were to work primarily with the French and as we depended to a great extent on them for our ammunition supply, it was but natural that we should adopt practically their method of supplying munitions, which, as I understand it, was in reality a separate service functioning under the Fourth Bureau of their General Staff.

Since, in our service, munition duties have always been a part of our Ordnance Department, it appears only natural that we should in the future give back to the Ordnance Department these munition duties. To do otherwise would be to attempt to provide another service where one now stands ready and organized to do the work.

At least down to the corps there is no need of introducing the term "munitions officer," for the ordnance officers of the various units, and those in the communications zone and zone of the interior are the proper persons to function munitions from manufacture to delivery. The exact place of this delivery to combat troops will be discussed later.

As an example of the above, it may be said that the army munitions officer of overseas is the same officer who is now defined as the assistant to the Army Ordnance Officer in charge of ammunition depots. This officer, under the supervision of the general staff, is charged with all the duties of stocking, storing, alloting and issuing ammunition within the army. The general staff gets its policy from the Chief of Artillery of the Army.

In my opinion it should also be the ordnance officers of corps and divisions who should be the supply officers for munitions, functioning as services under the general staff in the same manner as they now function for other ordnance supplies. The necessary commissioned and enlisted personnel should be added to their offices in order to so function.

When we come to discuss the question of ammunition trains, the matter is not so simple and involves many different points. The first point, however, is one on which at least all artillerymen agree, namely, that ammunition train personnel must be specially trained for this work. They cannot be merely motor truck personnel trained for cargo carrying. They must have training in care, handling and knowledge of munitions and how to deliver them, regardless of the complexity of the situation.

A complete reading of my article in the *Journal of U. S. Artillery* will show that from my experience overseas I believe that the manning of trains from the artillery is entirely satisfactory. It is possibly immaterial from what branch of the service they come as long as they are trained. Nevertheless, I rather favor the use of artillerymen for this work, as I believe that artillerymen will better visualize their job from the viewpoint of the artillery which they must serve than would supply troops such as the ordnance personnel.

Following our Field Service Regulations and our practice overseas, the responsibility for ammunition supply has been placed on the army commander for the army, on his chief of artillery for the army artillery, and on the chief of artillery of the corps for the corps and divisional artillery. The responsibility being his, the trains must be under his command. Thus, as an example, we find the Corps Artillery Park under the Chief of Artillery of the Corps.

The doctrine in the artillery has, moreover, been that all pieces should be put into position for action to assist the infantry to attain its mission. There is normally no reserve of guns held out in an action. The reserve is the fire power capable of being developed where needed, and is then the reserve of ammunition. For this reason, the artillery has demanded the control of the ammunition trains when action is imminent in order to control what they have considered their reserve. Today this includes the Corps Artillery Park.

Somewhere is the chain of supply, the supply department must deliver the supplies to the control of the combat troops, who make the actual deliveries. In nearly every

class of supplies this point of change is the regiment or separate battalion, and for this purpose we find the supply company a part of the regiment. Were it not for control of the trains demanded by the artillery in the case of munitions, it would appear that this would be the proper place for the ordnance department to deliver the ammunition.

We must furthermore not lose sight of the great desirability of forming units as far as possible all from one branch of the service; this is particularly illustrated in the formation of the regiment in which nearly every specialist is from the infantry. In this connection I have never believed it wise to depart from this rule to attach ordnance personnel. In my opinion, they should be specially trained infantry personnel capable of doing the ordnance work necessary.

We also know that a commander must be supreme and command all units. Whatever be the branch of the service from which the manning troops of the ammunition trains come, they must be division troops, absolutely under the command of the division.

The point brought out most strongly in the closing paragraphs of Colonel Stuart's article is the necessity of having ammunition train personnel from the Ordnance Department. This, of course, includes those of army artillery, corps and divisions. From what has been said above I cannot see any particular advantage in changing from the artillery to the ordnance for this duty. In fact, I favor the artillery personnel in that position. But I do lean toward the opinion that the artillery reserve is the ammunition carried in the regimental combat trains and does not include that carried in the division trains. In fact, it appears to me that the artillery with its combat train allowance has the reserve contemplated by regulations. All over and above that becomes merely a supply matter, a munitions supply matter, and one that rightly belongs as a function of the supply department charged with supplying munitions, namely the Ordnance Department. For this purpose the ammunition trains of army artillery, corps and divisions should function under the respective ordnance officers in the same way that the supply trains function under the proper quartermasters. This places the supply of munitions as an ordnance function under general staff control in a manner similar to all other supply services. It is realized that this opinion is contrary to that recently incorporated in the reorganization of the army, in that under new organization, artillery ammunition trains are to become a part of artillery brigades, but my experience overseas makes me believe that it is the correct way to function munitions.

Field Service Notes

Sale of Ordnance to Reserve Officers.

Advance notice has been received from the Adjutant General of the Army to the effect that in the next revision of the Regulations governing the Officers' Reserve Corps, authority will be given to make sales of small arms and equipment to members of that Corps. No sales, however, will be made until this publication, in its revised form, is available.

New Construction.

The construction of the ammunition storage depots at Savanna, Ill., and Ogden, Utah, is progressing rapidly. According to latest progress reports from Ogden, there are three buildings under roof and all under construction. At Savanna Proving Ground eight magazines are under roof, housing is 60 per cent complete and all under way. The storage pit at Savanna for nitrate has been completed, and arrangements are being made for the shipment of the nitrate from present storage points. It is expected that this movement will start about March 1. This includes approximately 7,000 carloads of nitrate to Savanna from various points on the Atlantic and Gulf coasts, approximately 2,500 carloads of ammunition to Savanna and 1,600 carloads of ammunition to Ogden from various points on the Atlantic Seaboard. During the past month plans have been completed for the shipment of ammunition to these depots, and also for the redistribution of stocks among the other depots. A chart has been issued showing quantities of the principal types to be shipped to and from the several depots. Other charts will be issued in the near future covering the remaining types. General instructions covering this movement have also been issued. Maj. O. H. Presbrey, Ordnance Department, has been ordered to Ogden Arsenal as Commanding Officer of that establishment.

Sundry Civil Bill.

Estimates were submitted to Congress in the Sundry Civil Bill for the construction of thirty-three additional magazines at Ogden, and forty-three at Savanna Proving Ground, and also for the construction of the one hundred ninety-nine high-explosive magazines formerly intended for Sparta, Wis., at Fort Wingate, N. M. Inasmuch as the Sundry Civil Bill, as reported from the House Appropriations Committee, does not contain items covering any of these projects, it is not expected that the magazines will be authorized this year.

Riot Guns for Corps Areas.

The distribution of riot shotguns, in accordance with instructions received from the Adjutant General of the Army, which provide for a supply of 1,000 shotguns of this type to be held by the Commanding General of each of the Corps Areas and 400 in the Hawaiian Department, for use in case of riot duty, is practically completed.

Organization tables for Ordnance companies (maintenance and cavalry maintenance) have been compiled, approved and submitted to the General Staff for publication.

The Gage Problem in Ordnance Manufacture

By

J. O. JOHNSON
Member A. O. A.

[The vital importance of having immediately available at the outbreak of war sufficient gages to permit an early start upon the manufacture of various units and components of Ordnance has been recognized by the formation of a Gage Section operating directly under the Chief of Manufacture, Ordnance Office. On the formation of this Section in November, 1919, the author of this article, Maj. J. O. Johnson, was assigned as its first Chief, and since that date all questions relating to gages have been handled by the Gage Section instead of by the various manufacturing divisions as incidental to the manufacture of the particular types of material which they are charged with producing. In short, gages are recognized as a definite problem, justifying the formation of a separate unit charged solely with solving problems relating thereto.—ED.]

IT was the experience of the Ordnance Department during the World War that delays in getting into quantity production were very largely due to the impossibility of securing proper gages for controlling the accuracy of manufacture, as well as determining the conformity of the manufactured materiel to the specifications governing its inspection for acceptance. This situation arose from the fact that at the outbreak of war there was not in the whole United States of America anything like the number of gage designers, tool makers, or shops equipped to manufacture gages commensurate with the magnitude of the problem in highly accurate and highly interchangeable manufacture required by the munitions program.

Gaging is recognized as being the most highly specialized branch of the tool-making industry and is an art difficult to master even with long training and experience. It requires an extensive manufacturing experience on interchangeable work and an intimate knowledge of the various operations and processes of machining. It requires also a thorough understanding of the theory of tolerances and the exercise of sound judgment in its application, in order that the manufacturer may have as large a working range as possible and yet insure that the finished article will function as intended and will be interchangeable within the prescribed limits.

In order to be always in a position to start the quantity production of types of Ordnance used during the World War, the Department is devoting a great deal of its attention to conserving the the gages which were made for this purpose and which also will serve as models for the design of gages for such material, generally similar but probably of improved design, as may be developed in the future. It is the purpose of this article to outline briefly the steps taken by the Ordnance Department to accomplish these ends.

The order establishing the Gage Section provided:

* * * * * *

2. The Chief of the Gage Section shall be responsible for the development, design, procurement, inspection, alteration, upkeep, storage and supply of all gages, and for all other duties incident thereto, as are assigned to a Manufacturing Division in Office Order No. 495, January 7, 1919.

3. There shall be transferred from the Manufacturing Divisions to the Gage Section, all personnel records, and correspondence pertaining to gages, which transfer shall be effective upon the request of the Gage Section.

* * * * * *

The first big problem of this Section was to collect all gages belonging to the Ordnance Department from the settlement of claims. These gages, which were scattered all over the country and in all sorts of condition (estimated value about thirty million dollars), had to be gathered into Government arsenals, and in order to save confusion it was decided to establish the different arsenals as receiving and storage depots for certain kinds of gages pertaining to the materiel manufactured at the arsenal. Accordingly, the following General Instructions were issued January 17, 1920:

The following general instructions will be followed at each Ordnance establishment covering the handling of gages assigned to that particular Ordnance establishment.

In general, the gages are assigned to the various arsenals according to the schedule listed below:

Rock Island Arsenal. Gages pertaining to carriages for mobile artillery up to and including 8-inch howitzer carriages, and caterpillar mounts; gages pertaining to tanks, tractors, trailers and trucks; gages for the small-arms manufacturing facilities now installed at Rock Island Arsenal, and gages for drop-bomb-release mechanisms.

Frankford Arsenal. Gages pertaining to small-arms ammunition; gages pertaining to all artillery ammunition with the exception of gages for shell larger than 240 mm. caliber, which go to Watertown Arsenal; gages for sights and fire-control instruments, including bomb sights, measuring and gage-checking instruments; gages for trench warfare ammunition, and drop bombs including detonating systems.

Note. While the Frankford Arsenal is designated as the center for gages for ammunition, as a temporary measure it will be necessary to utilize facilities at Chicago Storage Depot for the handling of the gages now in storage there and which may be shipped there in the near future, but ultimately it is the intention to transfer these activities, together with the gages, to Frankford Arsenal. Arrangements at Frankford Arsenal should be of such a nature as to take care of this additional work at a later date when it becomes practicable to make the change.

House of Representatives U. S.
Washington, D. C.

Even before the outbreak of the great war in Europe, earnest students of military problems had begun to realize that, in the event of a war of any considerable magnitude, the task of supplying the necessary matériel would be greater and more difficult than that of making ready the required personnel. The experience of the war more than demonstrated the truth of this proposition. The varied character, as well as the stupendous quantities, of arms and ammunition used in the war, far surpassed the wildest dream of the most advanced thinker along military lines.

In considering the question of a sane, safe, adequate and reasonable preparation for the national defense the two primary elements of warfare should be taken up in the order sung by Vergil in the opening line of his immortal epic, "*Arma virumque.*" The quick production of proper ordnance in adequate quantities when needed is the crux of the problem of national defense, and gages are the most vital requisite in working out this problem. Major Johnson does well to call the attention, as he does in this article, of military men, and of captains of peaceful industry as well, to the importance of this matter. By reason of his long and practical experience he is peculiarly well qualified to deal with this subject. I commend his article to all those who are interested in the practical problem of military preparedness.—JOHN Q. TILSON, *Member of Congress, Third District, Connecticut.*

Picatinny Arsenal. Such special gages of various kinds as are actually needed at Picatinny Arsenal in the experimental and development work pertaining to that arsenal.

Watertown Arsenal. Gages pertaining to seacoast carriages; gages pertaining to the 240 mm. howitzer carriage and heavier howitzer carriages; gages pertaining to railway artillery carriages; gages pertaining to projectiles of larger caliber than 240 mm.

Springfield Armory. Gages pertaining to all rifles, machine guns, automatic rifles, pistols and revolvers and accessories therefor, not including ammunition. This does not include the gages needed for the production units for small arms actually installed at Rock Island Arsenal.

Watervliet Arsenal. Gages pertaining to cannon and accessories therefor.

Chicago Storage Depot. While Frankford Arsenal is prescribed as the gage center for gages for artillery and trench warfare ammunition and drop bombs, it will be necessary to temporarily use the facilities at the Chicago Storage Depot for handling the gages that have already been shipped there and that will be shipped there as a matter of expediency. The work at the Chicago Storage Depot should proceed according to this order, but special instructions will later be issued to that arsenal as to the action to be taken in connection with the transfer of the activities to Frankford Arsenal.

When gages are received at any of the arsenals the boxes should be immediately opened and the gages examined to see their condition; if necessary they should be temporarily slushed while awaiting inspection and test.

When the gages are turned over to the gage unit they should be checked within a reasonable time, care being taken to insure the latest revised drawings being used. The checking of the gages should cover positive identification of the gages, inspection as to accuracy, recording of necessary data on cards, and examination as to condition—doing necessary cleaning, slushing, and storing in bins according to the system prescribed at the arsenal in question.

In recording the data pertaining to the gages the fundamental idea is as follows: the gage having been cleaned, checked and slushed, is stored and thereafter is represented by the data card, which should contain as much information concerning the gage as could be obtained from a physical examination of the gage itself. A form of card is prescribed which shows the data necessary to be recorded in order to achieve the above purpose.

Four cards will be prepared to give the complete data as prescribed. One of these cards will be forwarded to the Gage Section, Executive Division, Office of the Chief of Manufacture, Washington, D. C. The remaining three cards will be used by the arsenal authorities in keeping proper check of the gages.

The following method will be followed in the use of the three remaining cards, this method having been adopted after consultation with certain of the arsenal authorities:

One of the cards to be filed under the identification number.

One of the cards to be filed under the gage name or designation.

One of the cards to be filed under the component for which the gage was designed.

If the arsenal authorities consider any additional cards desirable or necessary, sample cards should be submitted to this office for approval before being put in use.

When a gage is cleaned, tested and listed on the data cards, an identifying number will be etched on the gage by an etching machine and the corresponding identification number will be entered on the data cards. This is an important point, being the only identification link between the gage itself and its corresponding data card.

In connection with the slushing and storing of gages, attention is invited to the importance of using a slushing compound that is free from acid and as free from moisture as can be obtained. Great care should be taken in applying the slushing compound to the gage, preferably by dipping while the compound is heated to a molten condition. After dripping and allowing to cool, the gages should be wrapped in moisture-proof paper.

When a gage is inspected and found unserviceable but of sufficient value to render reclaiming advisable, the gage should be set aside pending instructions from Washington. After repairing it will then be listed and entered in the same manner as other serviceable gages. The actual work of repair for reclaimed gages should not take precedence over the testing or inspection of the remainder of the gages, but should be postponed until after all the gages have been inspected, listed, and stored, unless special conditions at an arsenal render other steps advisable.

When a gage is found unserviceable and not worth reclaiming, it will be scrapped and disposed of under existing regulations, its card being forwarded to Washington to show the disposition made.

In connection with the general subject of inspecting and storing gages, the idea must always be kept in mind that the gages must be so stored as to be easily available for shipment in sets or in such other manner as may be required.

The above instructions apply to gages which pertain to material which has been accepted as standard, that is approved Ordnance material for issue. Gages for experimental work will not be placed in the same category as gages for standard material. Where gages are found that do not pertain to standard material the facts should be reported to this office with request for instructions as to disposal and record.

The attention of all arsenals is invited to the necessity of completing the work prescribed in this order by June 30th as funds will not be available after that date. In case any conditions exist which will prevent the completion of the work by June 30th, a special report should be made to this office showing reasons therefor.

It is important at the present time that every effort be made to properly test, check, record and store the gages on hand. Later, after the gages have been properly taken care of, the question as to what gages we have on hand, the completeness of various gage sets, and questions of like import will be covered in separate instructions.

Any difficulties encountered in the arsenals in carrying out the above instructions should be made the subject of special report to this office.

In the meantime, these arsenals were equipped with up-to-date facilities, and trained personnel was secured as far as possible. Very rapid progress has been made, and at this writing the expectation of the Gage Section is to have this work completed by June 30, 1921. The net result from this work will be that the Ordnance Department, through the Gage Section, will be able to tell at any time just what gages they have on hand, the condition of each gage, and its exact location.

In case of emergency where quick expansion would be imperative, complete sets of gages on each component could be selected and distributed so that every contractor would receive his immediate needs which would hold him over until more gages could be made. By this method, the contractor would be ready to begin work as soon as his machines and equipment were arranged, and would save considerable time in getting into quantity production.

It may be well at this time to give a history of what has led up to the present efficiency in the manufacture of interchangeable parts.

The first interchangeable manufacture attempted was in France in the year 1717, and it failed. Another trial was made in 1785, which also failed. In 1798, Eli Whitney, of cotton gin fame, took and completed a contract to make ten thousand muskets for the United States Government, and the parts of these guns were interchangeable.

English and French Ordnance Officers ridiculed and criticised Whitney's ideas to such an extent that Congress became alarmed at the money being used for the purpose. Whitney went to Washington with ten guns, disassembled them, and distributed the parts on the floor. From these parts he then assembled ten guns that operated properly. This remarkable achievement astonished everyone, and is believed to be the first successful interchangeable manufacture of accurate work. As nearly as can be found from the records available, this occured in 1800. In 1808, Simeon North accomplished a like feat on pistols for the government. It is claimed by some that he was the first to introduce it.

It is also known that John George Bodmer began to manufacture guns at St. Blaise, in the Black Forest about 1806 by a new method, which is believed to have been partly interchangeable; that is, some of the parts like the lock and stock were made and carried in stock and are supposed to have been interchangeable. However, interchangeable manufacture is conceded to be an American development and is described by writers on the continent as an American method. In 1853, a British Commission visited the United States to investigate the methods in use and as a result ordered 20,000 Enfield Rifles for the British Government, and

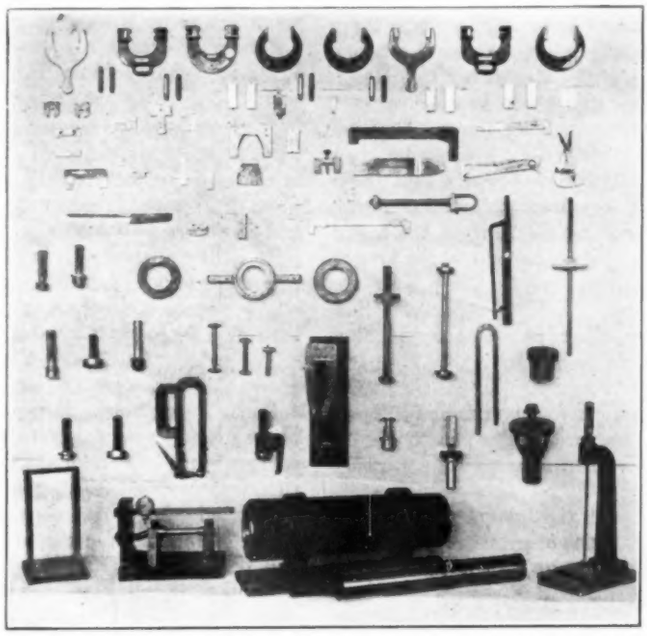
later 157 machines for the Government Arsenals. James H. Burton was hired to install the machinery and methods.

From this small beginning, the practice grew steadily in the armories and arsenals and later as the advantages became known, it spread to bicycles, typewriters and various other things until now it is quite common to speak of interchangeable manufacture. There is no doubt but that there is some difference between the exact meaning of the term then and now, just as there is a great difference between manufacture then and now. There are several degrees of interchangeability, or at least several interpretations of the the term.

Strict interchangeability consists in making the different parts of a mechanism so uniform in size and contour that each part will fit and properly function in any one of the whole number of mechanisms, no matter when or where it is made. It will be noted that this definition means that each part of the mechanism of a certain model will fit any of the mechanisms of the same model regardless of the lot to which it belongs or the year in which it was made.

Partial interchangeability consists in making each part fit any mechanism in a certain series; that is, the interchangeability exists only in the same series.

In the early days before the modern accurate machinery came into use, it was necessary to finish work by hand, and to make it uniform template filing and finishing was resorted to. For example, gun and pistol parts would have the holes drilled and reamed in a jig or fixture and then the contour finishing done by putting those pieces into template jig, provided with pins to fit the holes. The outside of the jigs would be a hardened duplicate of the shape and size of the model piece. The workman would then file down to the hardened template, which controlled the shape and size of the piece. Many ingenious devices and schemes were used to facilitate the duplication of parts and great skill was developed in the workmen.



"The 77 gages required to insure that a 75-mm. shell case conforms to specifications."

The great improvement in machine tools, especially as to accuracy of output, was a very great factor in promoting interchangeablility and, here again, America has led the world. The refinement, accuracy and efficiency of modern machine tools are strictly American accomplishments and are the outcome of demands for interchangeable manufacture at a low cost. American labor costs so much more than foreign that to compete in the world markets, we had to obtain as much product for each dollar of labor as our competitors; therefore, we had to develop machinery to get more product for less labor. This in turn has developed skill in our mechanics and raised the standard of living, so that to-day American skilled workmen are the best situated in the world.

It is a fundamental law that interchangeable manufacture is facilitated by allowing the largest possible freedom in the fit of mating parts consistent with proper functioning. This leads up to the subject of allowances and tolerances, one of the simplest but least understood in the whole system of interchangeability. As these two words will be used repeatedly, it is well to point out the difference between them.

Allowance is a prescribed difference between the dimensions of two mating parts to produce a desired kind of fit. Example: A standard hole exactly 1 inch in diameter, for a free running shaft, the diameter of which is .998 inch. The difference between this journal and the shaft is .002 inch and this is the allowance prescribed for the oil film.

Tolerance is the prescribed permissible difference in the dimensions to cover the unavoidable errors or variations in manufacturing a large number of pieces.

In the above example, if a thousand running fits were to be made, the holes might be dimensioned 1.000 inch $^{+.0005}_{-.0000}$ This half-thousandth permissible error is the tolerance.

The shaft might be dimensioned .998 $^{+ .0000}_{- .0010}$ and this permissible error of .001 inch is the tolerance. Then the minimum allowance is .002 inch and the maximum looseness or the sum of both tolerances and the minimum allowance is .0035 inch.

Thus the kind of fit is finally determined by the combination of the allowance and tolerance, and most engineers prefer to use allowance as a minimum value, which is never intentionally encroached upon, the tolerances providing for larger freedom of fits. The reason for this is that the data for minimum allowance is more reliable and has been more clearly demonstrated than the maximum allowance, and as it is vital, it must be unaffected by tolerances. This is plainly evident in the case of free moving parts, as it is well understood that a space must be provided for an oil film and this space must not be so small as to endanger failure through seizing of the parts in contact. Again, it has rarely been determined, except in individual cases, how loose moving parts can be before they are unsuitable. It must be understood also that the tendency of the engineer is in the direction of longer wearing life of the parts, hence the tendency to decrease maximum allowance or looseness.

There are many conditions in which maximum looseness determines the strength of the parts or the limits of engagement and any more freedom of fit would make the parts unsatisfactory. When this is the case, maximum looseness must be the starting point of the calculations, and this must then be unaffected by tolerances. Then, if minimum allowance can be determined, the difference between these two (maximum and minimum looseness) is the sum of the tolerances.

The tolerances are then divided between the mating parts according to the manufacturing ability to produce the parts to uniform size. That is, if the manufacturing ability is such that it is much easier to produce uniform size in one member than the other, the tolerance on the members is divided in direct proportion to this condition. When the dimensioning is finished, we will have the equation Maximum looseness=minimum allowance+the sum of the tolerance of both parts, and this equation will apply whatever the known factors are.

Very often the allowance has zero value—that is, there is no clearance whatever allowed for the fit and in a single pair of mating parts, they fit metal to metal. Now, if a large number of such parts are to be made, it must be determined whether this zero allowance is for the tightest or the loosest fit permissible, and then substitute the known values in the equation, maximum looseness=minimum allowance+tolerance of both parts.

The term "Negative Allowance" is often used to indicate that we allow a certain prescribed amount to make a tight or force fit, and is very confusing because it implies being subtracted and this is not the case. According to present usage, zero allowance indicates that there is no clearance or space allowed between the two mating parts. Positive allowance indicates that there is prescribed a space between the mating parts. Negative allowance indicates that there is less than a space provided for between the mating parts, or an imaginary space displaced by the flow of the metal to make a tight fit. Therefore, negative allowance should be treated as a negative quantity in the formula above mentioned and then the quantity resulting used for either greater or less looseness, according to whether the sign of the quantity is positive or negative.

As maximum looseness or minimum tightness is the smallest shaft in the largest hole or conversely minimum looseness or maximum tightness is the largest shaft in the smallest hole, we have the following formula, which covers all cases:

Maximum looseness or minimum tightness=minimum allowance or largest exterior member in smallest interior member+the sum of the tolerance of both parts.

The following example will make this plain: A hole is dimensioned $1.000''^{+.0005}_{-.0000}$ and its mating part $1.002''^{+.0000}_{-.0005}$ and as the shaft is larger than the hole, the sign of the allowance is negative and it will be a tight fit. In this case, what is the minimum allowance?

As already stated, it is the largest interior member in the smallest hole and is, therefore, equal to 1.002—1.000 with a minus sign or —.002″.

If the following procedure and method of dimensioning drawings be followed, it will greatly simplify matters pertaining to allowances and tolerances. Determine the minimum allowance or the difference to be allowed between the maximum internal and minimum external member of a single mating pair and make the dimensions on the drawings of the mating parts, before adding tolerances, agree with this. Using our first example for running fit, the hole should be dimensioned 1.000″ and the shaft .998″. This indicates at once a minimum allowance of .002″ for one pair of mating parts. Then, as this is maximum tightness or minimum looseness, tolerances for manufacture are added to the right of these figures and are for hole $1.000^{+.0005}_{-.0000}$ and for shaft $.998^{+.000}_{-.001}$.

Stating it another way, choose for the main dimensions the smaller one of the external member and the larger of the internal member and add tolerances in the direction to produce looseness of fit. If this method were followed universally, it would be less confusing and save endless argument and waste of time on setting tolerances.

The minimum allowance or greatest tightness and maximum looseness must be known when the tolerances have been set, and usually they are known at the time tolerances are set. There are, however, cases in which it is known that certain tolerances are the smallest that can be successfully used in manufacture and then maximum looseness and maximum tightness must be adjusted to obtain the best functioning condition in conjunction with these tolerances. This occurs often in very close work.

After determining the maximum and minimum looseness of mating parts and setting the tolerances, it becomes necessary to control the dimensions of the parts so that none of the dimensions will be outside of the limits established, and this is best done at this time for strictly interchangeable manufacture by the use of proper 'go" and "no go" gages.

First-class gages are expensive and soon wear so that strict interchangeability is sacrificed to keep down gage cost.

In times past it was common practice to use "go" gages only, limiting the looseness of fit by the shake of the piece in the gage. Where a little more refinement was needed, a piece of newspaper was used on one side of the "go" gage and if the piece which passed without the paper did not pass with the paper, it was accepted. A piece of newspaper used with each of a pair of mating "go" gages usually produced a freedom of fit of from .004″ to .006″ and with skillful help, it produced satisfactory results.

For strictly interchangeable quantity production work of good character, a good gaging system will prove economical.

Such a system comprises the minimum number of properly designed gages to control all the factors of the various parts of a mechanism so that they will assemble and function properly. As stated before, this assumes that proper allowances and tolerances have been established.

The minimum number of gages is usually a maximum and a minimum gage for each fit of a mating part and sometimes in addition a maximum and minimum length gage.

Sometimes intricate pieces have holes, guiding surfaces, bosses, and slides which must be in definite relation to each other. In this case, a type of functional gage would be used which should check the accuracy of relation of each of these elements to each other and especially to the important one.

Sometimes a complete mechanism is made of units each of which contains a number of parts all of which must function.

In a case of this kind, the parts are gaged and each unit assembled, then a functional gage checks the correctness of the entire unit after assembly so that the unit will function properly when the whole mechanism is assembled.

The designer should always keep before him the fundamental principle that tolerances should be as large as proper functioning will permit and he should be well informed what tolerances successful manufacturers actually work to. He should take pains to inform himself how tight and how loose working parts can actually be and yet give satisfactory results.

Once these tolerances are set as large as the designer will risk, they should be rigidly adhered to and considered a boundary line. The product should always be kept within

these boundary lines and this is best accomplished by making the component drawing dimensions the Inspection Gage dimensions.

Inspection gages are usually of the same design as the working gages, the exact amount to allow for wear is an economic problem. In solving it, one must keep in mind that a small wear limit increases the gage cost and a large wear limit requires closer attention and work at the machines.

Where experience is lacking, it is good practice to allow 10 per cent of the component tolerance for wear on the "go" gages. As the "no go" gages wear but little, 5 per cent will be sufficient. They can only represent extreme tolerance limits when worn to exact component dimensions.

The working gages are those used to check the work as it is machined, and should have liberal wear limits to insure the work being passed by the inspection gages.

Thus it will be seen that this system, if followed, will admit of the acceptance of work that will be interchangeable. It also emphasizes the fundamental principle that tolerances should be as large as will properly function.

If the tolerances are too small the work will be more costly because better workmen will be required, and this always means higher wages. Better tools and machines to produce the close work and more frequent adjustment and attention are also necessary, as well as additional gage cost.

Close tolerances cause large rejections of the work and more or less friction between the inspector and those responsible for the work. It must be understood that the inspector has but little choice in the majority of work as regards the dimensions. He is given a set of Inspection Gages which are the extreme limits of the dimensions the purchaser is going to accept and then he has no option but to pass everything within these limits and reject everything without. The trouble usually is that the inspector throws out work that is only one-thousandth of an inch outside the limit and the workman thinks this is unreasonable and the work just as good as that which barely passed the gage. The inspector, however, is right; the line must be drawn somewhere, and there is some point at which it becomes a risk to accept faulty material that will not function properly. This point is the limits of the Inspection Gage and should be all that the designer will risk for proper functioning. Then the judgment of the designer should be accepted and the limits rigidly adhered to, as he is responsible.

If the inspector accepts work that he knows is outside these limits, he and not the designer is responsible for any failure to function.

It must be understood that the best of interchangeable product is as close to the center of the tolerance allowed, and the poorest at the extreme, especially those mating parts which wear and a purchaser has a right to expect a large part of the contract to be of good quality. He consents to accept any work which is between the extremes, but he does not agree to take any which is known to be outside the prescribed limits and if he has to take this risk he should not be expected to pay more than salvage price.

Many manufacturers think that all of the tolerances shown on the drawing should be taken, and in attempting to do so have large rejections. The manufacturers who have had experience in interchangeable manufacture aim for near the center of the tolerance and then the remaining tolerance is left for wear of tools and inattention of operators. This method is very good practice—it produces better work, helps to train good workmen, and the product readily passes inspection. A marksman shooting at a target scores every shot inside the outer ring, but he does not score as much as if he hits the bull's-eye. The oftener he hits the bull's-eye the better marksman he is, hence he does not aim for the outer ring but the center, and the distance from the outside ring to the center is his tolerance, or the inaccuracy which allows him any score at all.

The good workman and the best manufacturers hit the bull's-eye often; that is, their work is not just on the line where it requires a decision of the Supreme Court to accept or reject it, but is enough inside to be sure of acceptance.

The value of a product so far as dimensions are concerned is its uniformity within the tolerances at a point where its functional performance is the best, and this is usually near the center of the tolerance. The manufacturer who consistently follows this rule is bound to establish a good reputation and obtain work in preference to those who always have trouble because they try to take all the tolerance and so have a wide variation in the work.

The illustration of the gages needed for the acceptance of a 75 mm. shell gives one an idea of the importance of the gage problem, and how necessary it is in time of peace to be prepared as far as possible with sets of gages for each piece of standardized Ordnance material.

It takes seventy-seven gages and checks at an approximate cost of $2,200 for this one particular shell which was used so extensively during the last war. Millions of these shells were manufactured and a number of sets of gages had to be provided accordingly.

Take all the rest of Ordnance material from a 22-caliber bullet to a 16-inch railway mount and one can picture the number of designs that have to be laid down and the tremendous amount of highly specialized engineering skill that is needed to provide gages for the Ordnance program.

A gage designer, in order to lay down practical and economical gages, must be familiar with shop practice and also with the very difficult problem of tolerances on interchangeable materiel. All this work should and could, to a large extent, be carried out before any emergency arises, when the element of time is not such an important factor.

The Gage Section activities will be devoted to these various engineering problems, developing new and more practical gages and tolerances, and eliminating the confusion that existed at the beginning of the World War. Its aim is to establish policies that will be capable of quick expansion should another emergency arise.

"'Twas Ever Thus"

The following extract from the report of a Commission appointed by Charles I relative to Arms and Armour, in 1631, brings to mind very forcibly the great difficulties experienced by the Ordnance Department, caused by lack of standardization of matériel and changes which were made from time to time for correction of defects, and is also of interest in connection with our new development program.

"And because we are credibly given to understand that the often and continued altering and changing of the fashion of arms and armour, some counties and parts of the kingdom having armours of one fashion and some of another, do put many of our subjects to a great and unnecessary charge and more than need requirable; for the avoiding thereof our will and pleasure is, and we do hereby appoint and command that hereafter there shall be but one uniform fashion of armour of the said common and trained bands throughout our said Kingdom of England and dominion of Wales, whereas any of the said Armours shall be supplied, and new made, and that form and fashion of armour shall be agreeable to the last and modern fashion lately set down and appointed to be used by the lords and others of our council of War (the patterns whereof are now and shall remain in the office of our ordnance from time, which is our pleasure likewise concerning guns, pikes and bandaliers whereof patterns are and shall remain from time to time in our said Office)."

Quoted by Sir S. D. Scott, in *The British Army.*

The General Supply Division, Field Service

By

L. D. BOOTH

Member A. O. A.

(Colonel Booth, the present Chief of the General Supply Division, Ordnance Field Service, was Ordnance Officer of our gallant Thirtieth Division from the date of its organization until October, 1918. In referring to the attack by this division, in co-operation with our Twenty-Seventh Division and the Australian Corps, upon the "impregnable" Hindenburg Line at Le Cateau General Pershing states in his final report, "In this attack, carried out on September 29 and October 1, the Thirtieth Division speedily broke through the main line of defense, and captured all of its objectives . . . ."

For his excellent handling of the problem of Ordnance supply in this operation, Colonel Booth was appointed Ordnance Supply Officer, Headquarters First Army, and later, Chief Ordnance Officer, First Army, in which capacity he served until April 20, 1919, the date of the disbandment of the First Army as an organization. From April until June, he was a member of the board appointed to prepare the Manual for Ordnance Field Service, which forms the basis of operation of that service to-day. Since July 1, 1919, he has served continuously as Chief of the General Supply Division, and, in addition served as Chief of Ordnance Field Service from August 20, 1920 until January 6, 1921, when he was succeeded by General Burr, the present Chief.—ED.)

Function of Division

THE function of the General Supply Division of Ordnance Field Service, subject to such restrictions as may be imposed by the General Staff, is to:

Establish, organize, operate, inspect and maintain reserve, intermediate, base and advance depots, or sections thereof in case of general depots, for the supply of all Ordnance supplies other than ammunition and explosives.

Direct the distribution and supervise the receipt, storage and issue of supplies other than ammunition.

Supervise the preservation from deterioration of Ordnance supplies other than ammunition.

Organize, train and control officers and troops for technical supply service.

Establish and maintain such salvage service as is necessary and consistent with regulations.

Generally speaking, the duty of the General Supply Division is to store and issue all equipment and supplies, other than ammunition, which have been assigned by the Secretary of War to the Chief of Ordnance for storage and issue to the service in general. This work divides itself into three phases, namely; storage prior to issue, preservation of supplies while in storage, and the distribution of the stores from the manufacturing plants through the reserve, intermediate and advance depots to the depots which actually make the issues to troops.

Supply System Based on War Experiences

When we entered the World War in 1917, not only had there been nothing published showing the general scheme for general supply depots in the zone of the interior, but there was almost no information available on the layout, organization and method of operation of depots for a theater of operations. As a consequence, our depot commanders began operation with an organization built partly on theory and partly on the experience of our allies. In order that a logical and efficient organization might be built up in as short a time as possible, it was realized that we must take advantage of the experience gained by our allies, consequently, several officers were sent to the British supply depots to make a thorough study of their system. From the reports of these officers, and from our own experience, as activities increased and our problems became more definite, we arrived at a very satisfactory, workable organization. When the Armistice was signed we had a system and organization built on sound principles. The Chief Ordnance Officer of the A. E. F., realizing this, sent out instructions immediately after the Armistice to all Ordnance officers commanding Ordnance establishments, or organizations, directing them to submit to his office detailed reports showing their organization and methods of operation, and to embody therein any recommendations for changes which they thought should be made. In April, 1919, a board of six officers was convened at Tours, the headquarters of the S. O. S., to study these reports and to then prepare a manual for Ordnance field service. The result is the "Provisional Manual for Ordnance Field Service," published by the War Department in September, 1919. This manual covers all phases of Ordnance work in the theater of operations, and at the same time is applicable to Ordnance work in the field in time of peace. That part of the manual which deals with the general supply system gives the layout for a typical general Ordnance depot, and describes the organization, method of operation and personnel required for Ordnance depots in the theatre of operations. Our present scheme of supply insofar as concerns storage classifications, depot organization, classification of stores and control of stocks in their movement from one depot to another, is based on this system as used in the theatre of operations during the war.

Outline of Discussion. In the discussion which follows, it is hoped to give the reader, without bothering him with details, a fair conception of how the General Supply Division performs its task of handling Ordnance stores from the time they are procured from the manufacturer until they are delivered to the troops. The subjects to be discussed are: Storage facilities, which classifies the different depots in the warehouse system with the kind of supplies in each; flow of supplies, which shows how the supplies move through the different depots to the troops; Ordnance provision system, which explains the method used to keep the depots supplied with stores, and to furnish information to the Ordnance office for its use in computing requirements of stocks; method used in making distribution to the troops; and preservation of supplies while in storage.

Storage Facilities

Storage for supplies prior to their issue is classified, *First, in the zone of the interior, as,*

(a) Reserve storage, which includes reserve depots designated as such by order of the Secretary of War, primarily

for the storage of the reserve supplies of the War Department. The termination of the World War left the Ordnance Department with an enormous amount of equipment and supplies on hand which would be of little value to the commercial world, but of great value to the nation in time of an emergency. These supplies were collected from the manufacturers and properly prepared for storage in the reserve depots. Ordinarily, a reserve storage depot has assigned to it only the supplies of a particular class. For instance, one depot will be designated to handle all fire control equipment, another all artillery pertaining to permanent emplacements, another all small arms and machine guns, another all mobile artillery pertaining to a tactical division, while to another would be assigned the heavy mobile artillery and motor equipment. The supplies are stored according to the Ordnance group system explained later in this article, except where complete unit equipment is required to be assembled for initial equipment of organizations. In the latter case the equipment is prepared and placed so as to ship out a complete unit with as little confusion and loss of time as possible.

(b) Intermediate storage establishments consist of such plants, arsenals, or depots as have been assigned to receive and store equipment and supplies in bulk. They act as wholesale warehouses to the area and station depots, and consequently are so located geographically as to give prompt service to the area which they serve. Normally these depots are required to keep supplies on hand sufficient to meet the requirements for three months. These establishments would also supply embarkation depots and depots located in the theatre of operations.

(c) Embarkation storage, which includes depots for the supply of overseas expeditions.

(d) The area storage establishments are those depots assigned to store all supplies and equipment needed by the troops of a given geographical area. Normally these establishments act as intermediaries between the intermediate depots and the station depots, but in some cases they make issues direct to troop organizations. They naturally carry in stock many classes of equipment depending upon the armament of the troops within their territory. This stock is fixed at a quantity sufficient to meet the requirements of the area for three months.

(e) Station storage consists of small depots which are used as the local distributing agencies for such supplies as are needed for the troops assigned to their respective stations. Stocks sufficient for one month's consumption are kept on hand.

Second, in the theatre of operations.

(a) Base Depots, which are the supply depots in the Base Section, Communications Zone, Theatre of Operations, that receive supplies from the Zone of the Interior, or other source extraneous to the Theatre of Operations.

(b) Advance Depots, which are the supply depots in the Advance Section, Communications Zone, Theatre of Operations, that receive supplies from the rear primarily for issue to the army.

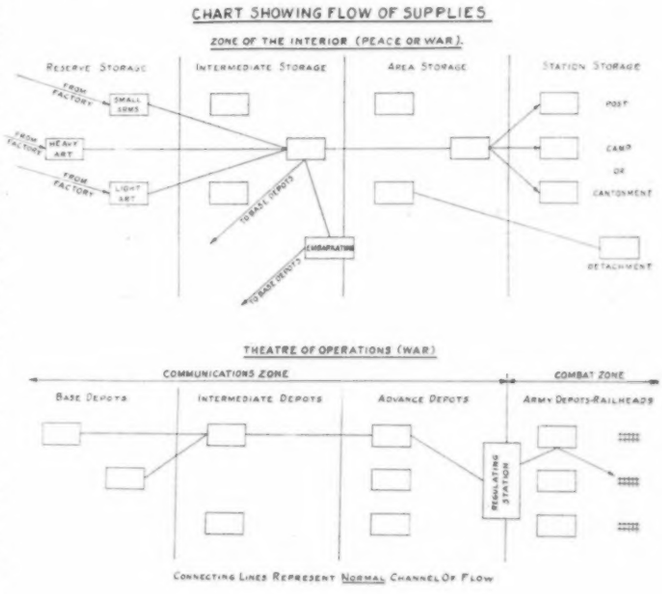
(c) Intermediate Depots, which are the Supply Depots in the Intermediate Section, Communications Zone, Theatre of Operations, which is interposed between the Base and Advance Sections when necessary because of extensive distance. In special cases the same depots may serve as Base and Advance Depots.

(d) Supply establishments in the Combat Zone, for supplies other than ammunition. These establishments are of two classes, Ordnance Shops, for supply of all parts needed by the shop personnel in making repairs, and Depots, for the supply of all other general equipment. These shops and depots issue direct to troops. Our experience in the World War taught us that it was essential to have general supply establishments in the Combat Zone for the troops to draw from instead of having supplies shipped to their railheads from the Advance Depots of the Communications Zone.

The stocks to be kept on hand in the depots of the combat zone would ordinarily be sufficient to meet the needs of the troops for a period of ten days or two weeks. The quantities to be kept in store in the other classes of depots would increase in each class as you go toward the rear.

Flow of Supplies

From the chart it will be seen that under normal



peace conditions the supplies come from the manufacturer to the reserve depots, thence to the area depots through the intermediate establishments. From the area depots they go to the station depots where they are issued to the troops. In time of war the base depots of the theatre of operations would be supplied by the reserve or intermediate depots, but through the embarkation depots in case of overseas operations. While this diagram represents the normal channel through which the supplies pass, it must be borne in mind that exceptions must be made to meet existing conditions. For instance, it might be necessary to make shipments of supplies direct from the reserve or intermediate depots to the station depots, or from one intermediate depot to another.

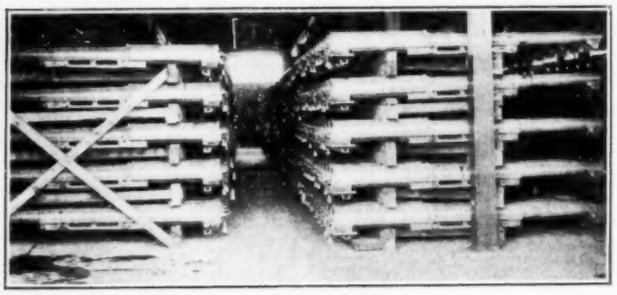
Depot Organization. In the above discussion an attempt has been made to explain the plan for housing supplies and the relation one depot bears to the other in the complete storage system. To accomplish the ultimate object of a general supply branch, which is to keep the troops equipped for action, an appropriate chain of warehouses must be supplemented by the necessary operating personnel and by simple and effective systems for receiving, issuing and accounting for supplies and for providing the depots with the required stocks. In this article it is not thought necessary to discuss the personnel organization and issue system as these are fully explained in the Manual for Ordnance Field Service. A brief description of the Ordnance

Provision System, adopted during the war, for maintaining stocks at the depots, will be given below.

Provision System

In the final analysis, the specific mission of the Ordnance Provision System is to maintain the stocks of supply establishments, under the control of the Chief of Ordnance, at their maximum authorized allowance. It may be defined as the operating machinery used by the depots in reviewing the status of their stocks and in transmitting this information, together with their demands for stock replenishment, to the Ordnance office, and by the Ordnance Office in filling the demands and tabulating the data needed for computing requirements. To properly perform its function a provision system must show first, the supplies on hand at each establishment; second, the demands for replenishment of stocks, and third, the issues for a definite period, the issue to other depots and to troops being shown separately.

In the operation of the provision system six blank forms are used; viz, Review Sheet, Abstract of Reviews, Consolidated Review Records, Dues in sheet, Dues out sheet, and Transfer Order. Where the number of different items handled runs into the thousands, such as is the case with the Ordnance Department, some logical arrangement in classes or groups must be made, and a nomenclature list for each group prepared.



75-mm. Guns in Storage

Recuperators for 75-mm. Gun Carriage in Storage

The arrangement adopted has been to list all supplies which are assigned to the Ordnance Department for storage and issue into a series of groups, each group containing major items of a similar character with the spare parts and accessories peculiar to each major item. Where parts, such as standard commercial items, are common to two or more major articles, they are placed in one general group. This is done to avoid dividing the supply of a particular item among several groups with the probable result of an accumulation in one group, and a shortage in another, unless an excessive amount be kept on hand. The following shows the present grouping of all Ordnance supplies:

Group A.

Machine guns, automatic rifles, 37-mm. guns, machine gun carts, including all accessories and appendages necessary to make the major item complete for use, including harness and pack equipment.

Group B.

Small arms, with all their accessories and appendages necessary to make the major item complete for use. Hand arms, with their scabbards and spare parts. Arm chests, arm lockers and arm racks. Tools for reloading small arms ammunition, complete. Arm repair chests, armorer's tool chests and pistol cleaning kits, with their contents.

Group C.

Mobile Artillery up to and including 6-inch calibers, with their carriages, mounts, caissons, limbers, reels, reel carts, battery and store wagons and sub-caliber guns, with all equipment necessary for operation and maneuvers. (Harness to be stored by Ordnance Department with reserve Divisions.)

Group D.

Mobile Artillery larger than 6-inch calibers, with their carriages, mounts, caissons, limbers, reels, reel carts, battery and store wagons, sub-caliber guns, Anti-Aircraft Artillery, trench mortars (except 4-inch Stokes), and all equipment necessary for operation and maneuvers. (Same as "C" for horse-drawn.)

Group E.

Railway Artillery and Artillery in permanent or semi-permanent emplacements with their carriages, mounts, cars, and all equipment necessary for operation and manuevers. Sub-caliber guns and sub-caliber cartridges. Saluting Guns. Articles of drafting equipment necessary for the complete equipment of such units as may be determined upon for reserve storage.

Group F.

Instruments used for range finding, control and observation of fire by Mobile troops and at permanent or semi-permanent emplacements, with their cases, pouches, chests and tripods, excepting sights for Aircraft machine guns. Storage and dry batteries used with fire control equipment. Field glasses and watches.

Group G.

Tanks, Artillery Tractors, Tractor and Trailer Caissons, Tractor Carts, Armored Motor Cars, Mobile Ordnance Repair Shop Trucks and Trailers, Light Repair Shop Trucks, Anti-Aircraft Machine Gun Trailers, Trailers for 75-mm. Gun and Limbers (for shop), 10-ton Trailers (for tanks), complete for original issue. Spare parts and accessories for above, except those specifically listed for issue by the Quartermaster Corps. Oxygen and acetylene gas used in Ordnance repair work.

Group H.

Targets, with all material and equipment necessary for operation. Special hand and machine tools and their spare parts and accessories; hardware, bolts, nuts; raw and partially finished material, sheet bars and billets that may be required for Ordnance work in the field and at Ordnance depots. Steel helmets and body armor. Oils for recoil mechanisms for Artillery. Special cutting compounds required for Ordnance work.

Group P.

Seacoast Railway and Anti-Aircraft Artillery ammunition (this includes all shell, propelling charges, primers and fuses necessary to make up complete rounds).

Group R.

Mobile artillery ammunition (this includes all primers,

fuses and propelling charges necessary to make up complete rounds).

Group S.

Trench warfare ammunition, excepting chemical ammunition used exclusively by Chemical Warfare troops, and aerial armament ammunition and pyrotechnics, bomb sights and bomb releases. (Complete rounds.)

Group T.

Small Arms ammunition. (Complete rounds.)

Group V.

High and low explosives, and raw materials therefor.

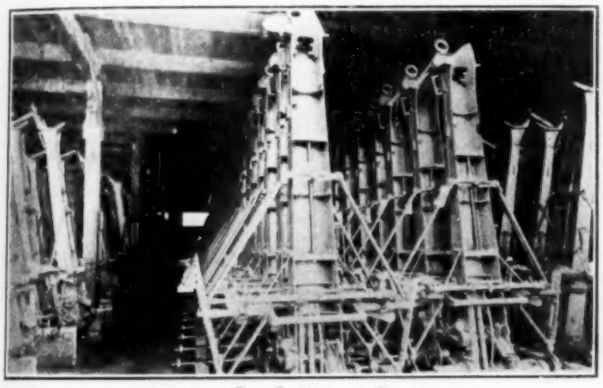
Group W.

Machined components of ammunition (shell, trench warfare, pyrotechnics, and miscellaneous components).

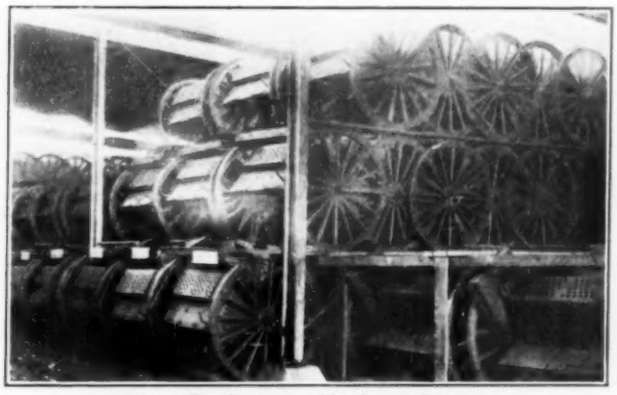
The nomenclature is published in Review Lists which are made out according to groups and each list contains the names, alphabetically arranged, of all parts pertaining to a particular major article.

The operation of the provision system is essentially as follows: A provision officer is appointed for each depot, who is held responsible that the stocks are maintained up to the authorized allowance. A Review Sheet is prepared for each and every item of property, and on the dates specified in the review schedule, published from the Ordnance Office, the status of the items is reviewed. This is done by transferring the necessary data to the review sheets from the stock record card, which is a card prescribed by the War Department as the permanent record in the property accounting system, and the dues-in and dues-out sheets. The completed review sheets are then sent to the office of the provision officer, where the consolidated reports known as Abstract of Reviews, are made. Each abstract contains only items pertaining to a single group. The abstracts from all groups are then collected and sent to the Ordnance Office. All depots review the same items on the same date, and when the abstracts are received in the Ordnance Office the information thereon is entered on the Consolidated Review Records, one sheet of which is provided for each item. When the abstracts from all depots have been entered, the status of each item is shown on one sheet. Transfer orders are then made out for the necessary movement of supplies. The total issues are shown on the Consolidated Review Record, and from the issues to troops the requirements for a specific period are computed.

The Ordnance Provision System Manual will, in the near future, be printed, and will contain a description of the system, a schedule for reviews, and a complete set of review lists showing the correct nomenclature for all Ordnance items. The complete book will be of service only to Ordnance establishments. Booklets will be made up of review lists peculiar to the different regimental or separate organizations for their use in making out requisitions.



75-mm. Gun Carriages in Storage



75-mm. Gun Caissons and Limbers in Storage

Distribution to Troops

(a) In the zone of the interior,

When supplies reach the area and station depots they come under the control of the officer commanding troops. These are the depots which make issues direct to troops on requisitions approved by the commanding officers of the organizations. With the exception of certain regulated stores, the issue of which must be approved by higher authority, the issue depots keep on hand a local stock sufficient to meet the needs of the organizations they supply for a period of one month.

Requisitions for regulated stores and for replenishment of stocks in the area and station depots are submitted to the Headquarters of the area in which the depots are located. After approval they are then sent to an intermediate depot for supply, except where the requisition calls for articles the issue of which must have the approval of the Chief of the branch concerned. The requisition procedure for ordnance stores is covered by Ordnance Field Service Bulletin No. 2, revised April 27, 1920.

(b) In the Combat Zone.

The Army depots make the issues to troops. Requisitions for regulated stores and for replenishment of stocks for the depots are sent to the Headquarters of the Army, or independent force, and after approval are sent, through the regulating office, to the advance depots, communications zone, for supply.

Preservation of Supplies in Storage

It goes almost without saying, that one of the inherent responsibilities of any organization whose function it is to store and issue supplies is that of properly preserving the same from deterioration or damage while in storage. This responsibility, where vast quantities of stores are concerned, and where the supplies are subject to a prolonged period of storage, is of the utmost importance. Under our present organization the General Supply and Maintenance Divisions are jointly responsible that there is no deterioration or damage of equipment and supplies while in storage. The work of the Maintenance Division is essentially of a technical nature, while that of the General Supply Division requires primarily the exercise of care and good judgment in the performance of its duties.

Consequently, the dividing line between the duties of the two divisions is not hard to fix. The General Supply

Division discharges its responsibilities by the selection of the proper kind of storage for the different classes of supplies, by the timely turnover of articles according to their perishability, and by the application of preservatives such as paints, greases and oils except when the condition of the article is such that a general overhaul is required, in which case it is turned over to the Maintenance Division to be put in proper condition. The Maintenance Division is responsible for the inspection and maintenance of supplies of a nature requiring the attention of mechanics, such as recuperators, gas engines, fire control instruments, etc., and for the repair of damage to supplies in store or about to be stored. The Ordnance Department is charged with the storage and issue of a class of supplies which is almost wholly technical and ranges from the large railway artillery guns and equipment down to delicate optical instruments and watches. In looking over this list of equipment one must appreciate the fact that the different classes of articles require storage facilities of a different class for their proper protection. For instance, the delicate optical instruments are easily damaged by dust, moisture and excessive changes in temperature. Such instruments must be stored in warm, dry places free from dust and grit. Certain classes of supplies, such as rubber tires and leather components, will deteriorate by prolonged storage, so it is essential that articles of this nature be given a timely turnover. Issues are made from the articles which have been longest in stock, and the replacement made by new stocks. All gas engines must be periodically turned over and all highly polished and bearing surfaces of all equipment carefully inspected and oiled to insure against rust and consequent deterioration. These duties are performed under the supervision of the trained personnel of the Maintenance Division.

Storage of Supplies for the Army

Under authority of Section 9, National Defense Act, as amended by Act of Congress, June 4, 1920, the following policy regarding procurement, storage, and issue of supplies has been announced by the War Department.

The term "*supplies*" will be understood to include all raw materials, commodities, manufactured articles, means of transportation, and assemblages of articles necessary for the Military Establishment. Supplies are divided into *general supplies*, embracing all supplies of standard manufacture and those common to two or more branches of the Army; and *special supplies*, embracing those special or technical articles (in process of development or not commercially standardized) issued or used exclusively by any one supply branch.

Storage in the zone of the interior is classified as: *Reserve storage*, which includes reserve depots designated as such by the Secretary of War, primarily for the storage of the reserve supplies of the War Department; *intermediate storage*, which includes depots, whether located at Government manufacturing plants or elsewhere, for the collection and storage of supplies primarily for issues in bulk to territorial commands and theaters of operations; *embarkation storage*, which includes base depots, primarily for the supply of oversea expeditions; *area storage*, which includes such depots as may be specifically assigned by the Secretary of War for the storage and issue of supplies solely within the limits of particular territorial commands; *station storage*, which includes post, camp, and station storage facilities for the local issue of supplies to troops.

General depots are those containing supplies stored by more than one supply branch; and the parts thereof assigned to supply branches for storage are designated as sections with appropriate names. *Branch depots* are those containing supplies assigned for storage to a single supply branch, and will be distinguished by the name of the appropriate supply branch.

Under the policy governing procurement, the Quartermaster General procures all general supplies and all storage space required by the War Department. Chiefs of supply branches procure such special supplies pertaining to their respective branches as may be directed by order of the Secretary of War. They furnish the Quartermaster General with all necessary information pertaining to *general* supplies procured by him for their respective branches, including statement of requirements; time of delivery; specifications, packing size and weight; such technical officers as may be necessary for inspection during manufacture and for acceptance, to be detailed by order of the Secretary of War; and shipping instructions, when required, giving destination of articles after procurement.

Under the policy governing storage, storage space in the zone of the interior is allotted to the supply branches by order of the Secretary of War. The Quartermaster General keeps adequate records of all storage space owned or leased by the War Department, including its disposition and utilization. The chief of each supply branch having storage functions makes application to The Adjutant General of the Army for any additional storage space that may be required from time to time by his branch, and also reports to The Adjutant General of the Army whenever any storage space allotted to him becomes surplus.

Existing depots which are to be continued have been designated and classified by order of the Secretary of War as follows:

GENERAL RESERVE DEPOTS.

Charleston General Reserve Depot, Charleston, S. C.; (a) Columbus General Reserve Depot, Columbus, Ohio; New Cumberland General Reserve Depot, New Cumberland, Pa.; (a) Schenectady General Reserve Depot, Schenectady, N. Y.

BRANCH RESERVE DEPOTS.

Ordnance Department.

Aberdeen Ordance Reserve Depot, Aberdeen Proving Ground, Md.; Amatol Ordnance Reserve Depot, Amatol Arsenal, N. J.; Curtis Bay Ordnance Reserve Depot, Curtis Bay, Md.; Delaware Ordnance Reserve Depot, Pedricktown, N. J.; Erie Ordnance Reserve Depot, Erie Proving Ground, Ohio; Frankford Ordnance Reserve Depot, Frankford Arsenal, Pa.; Middletown Ordnance Reserve Depot, Middletown, Pa.; Old Hickory Ordnance Reserve Depot, Old Hickory Arsenal, Tenn.; Penniman Ordnance Reserve Depot, Penniman, Va.; Pig Point Ordnance Reserve Depot, Pig Point, Va.; (a) Raritan Ordnance Reserve Depot, Raritan Arsenal, N. J.; Savanna Ordnance Reserve Depot, Savanna Proving Ground, Ill.; Seven Pines Ordnance Reserve Depot, Seven Pines, Richmond, Va.; Sparta Ordnance Reserve Depot, Sparta, Wis.; Toledo Ordnance Reserve Depot, Toledo, Ohio; Tullytown Ordnance Reserve Depot, Tullytown, Pa.; Wingate Ordnance Reserve Depot, Wingate, N. M.; Woodbury Ordnance Reserve Depot, Westville, N. J.

Chemical Warfare Service.

(a) Edgewood Chemical Warfare Reserve Depot, Edgewood Arsenal, Md.

Air Service.

Curtiss Elmwood Air Reserve Depot, Buffalo, N. Y.; Long Island Air Reserve Depot, U. S. Aeronautical Engine Plant, Long Island City, N. Y.

GENERAL INTERMEDIATE DEPOTS

Atlanta General Intermediate Depot, Atlanta, Ga.; Boston General Intermediate Depot, Boston, Mass.; Chicago General Intermediate Depot, Chicago, Ill.; New Orleans General Intermediate Depot, New Orleans, La.; New York General Intermediate Depot, New York, N. Y.; Norfolk General Intermediate Depot, Norfolk, Va.; San Francisco General Intermediate Depot, San Francisco, Cal.; Seattle General Intermediate Depot, Seattle, Wash.; St. Louis General Intermediate Depot, St. Louis, Mo.; Washington General Intermediate Depot, Washington, D. C.

BRANCH INTERMEDIATE DEPOTS.

Ordnance Department.

Augusta Ordnance Intermediate Depot, Augusta Arsenal, Ga.; Benicia Ordnance Intermediate Depot, Benicia Arsenal, Cal.; Rock Island Ordnance Intermediate Depot, Rock Island Arsenal, Ill.; San Antonio Ordnance Intermediate Depot, San Antonio, Tex.

Air Service.

Americus Air Intermediate Depot, Americus, Ga.; Fairfield Air Intermediate Depot, Fairfield, Ohio; Little Rock Air Intermediate Depot, Little Rock, Ark.; Middletown Air Intermediate Depot, Middletown, Pa.; Montgomery Air Intermediate Depot, Montgomery, Ala.; Richmond Air Intermediate Depot, Richmond, Va.; Rockwell Air Intermediate Depot, San Diego, Cal.; San Antonio Air Intermediate Depot, Kelly Field, San Antonio, Tex.

Quartermaster Corps.

Baltimore Quartermaster Intermediate Depot, Baltimore, Md.; Jeffersonville Quartermaster Intermediate Depot, Jeffersonville, Ind.; Omaha Quartermaster Intermediate Depot, Omaha, Nebr.; Philadelphia Quartermaster Intermediate Depot, Philadelphia, Pa.; Pittsburgh Quartermaster Intermediate Depot, Pittsburgh, Pa.; (b) Holabird Quartermaster Intermediate Depot, Camp Holabird, Md.; (b) Jesup Quartermaster Intermediate Depot, Camp Jesup, Ga.; (b) Normoyle Quartermaster Intermediate Depot, Camp Normoyle, Tex.; (c) Front Royal Quartermaster Intermediate Depot, Front Royal, Va.; (c) Keogh Quartermaster Intermediate Depot, Fort Keogh, Mont.; (c) Reno Quartermaster Intermediate Depot, Fort Reno, Okla.; (c) Robinson Quartermaster Intermediate Depot, Fort Robinson, Nebr.

GENERAL AREA DEPOTS.

Eighth Corps Area.

Eighth Corps General Area Depot No. 1, El Paso, Tex.; Eighth Corps General Area Depot No. 2, San Antonio, Tex.

Hawaiian Department.

Hawaiian General Area Depot.

Panama Canal Department.

Panama General Area Depot.

Philippine Department.

Philippine General Area Depot.

Notes: (a) Will function also as an Intermediate Depot until such time as distribution of supplies into intermediate storage can be made. This refers to Engineer supplies only at the Columbus and Schenectady General Reserve Depots.

(b) Motor.

(c) Remount.

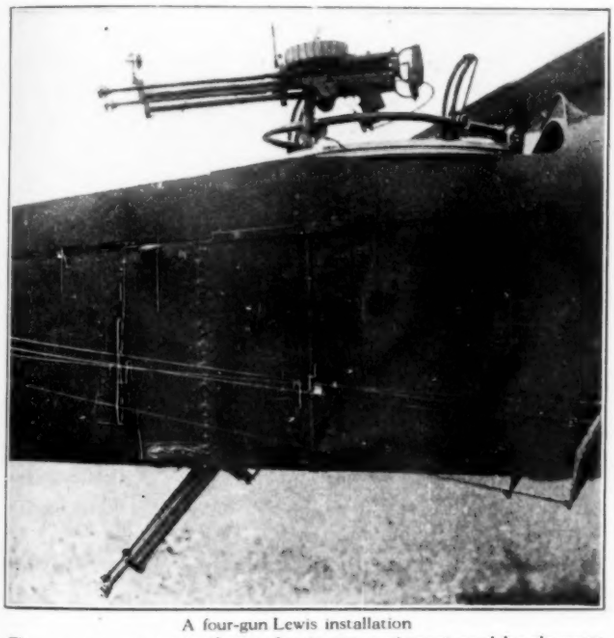
Aircraft Machine Guns

By

WALTER T. GORTON
Member A. O. A.

[Captain Gorton is in charge of the design and development of Aircraft Machine Guns, at the Dayton Branch, Aircraft Armament Division, Ordnance Department.—ED.]

THE machine gun is the premier weapon in the struggle between the fighting forces of the air. Other weapons, such as bombs and larger calibered guns of special design are used in attacking ground targets and in meeting attacks from the ground, but the airman depends on his machine guns in his endeavor to destroy enemy fliers and, while thus busily engaged, to prevent his own destruction by opponents equally determined and enterprising. It is interesting to note that when opportunity offers he also occasionally finds it extremely useful for shooting up such ground targets as trenches, columns, trains, and in general any target which can be raked and is susceptible to damage by machine-gun fire. Other weapons have been tried, and some of them, as for instance, the 37-mm. gun, may prove very useful, but there is every indication that the mainstay in aerial fighting will remain what is now, and has been since the first trial, the aircraft machine gun. It will not be, however, simply a machine gun attached, in a more or less makeshift way, to the plane which carries it, but an *aircraft weapon*, designed and built for this use and no other. The distinction is important and will be discussed more in detail later in this article.



A four-gun Lewis installation
The upper mount carries the usual twin gun equipment used by observers

A classic example of synchronized machine gun installation used by American pilots in the World War. Twin Vickers guns mounted in Spad pursuit plane

Why the machine gun should be the weapon par excellence for combat in the air is a question which naturally arises. The reasons are two in number: namely, the airplane and the machine gun itself. As a target the airplane is easily damaged by machine-gun fire—as it is, indeed, by any other fire which registers a hit. The obvious difficulty is to make hits upon it. Speed is the essence of the performance of a plane in flight, and, consequently, a rapid-firing gun, which can be easily trained, is the only style of weapon suitable for use against it. As a gun mount, the airplane is beset with the many limitations imposed by its own peculiar characteristics. Space is at a premium, only very little weight can be carried, and structural considerations prohibit any great amount of recoil. The only possible solution for the problem thus presented is the machine gun. It is the only effective weapon which can be readily carried, and the coincidence is that it happens to be a very effective one. Aerial fighting, then, is machine-gun fighting, and inherently so. This fact does not tend to make it any the more comfortable.

How did it all start? Needless to say, it was not brought into being by a careful theoretical analysis of the tactical requirements and the means at hand for meeting them. Far from it. In a melee the procedure long established as orthodox is to use with enthusiasm whatever implement happens to be handy, and in the case in point this is exactly what was done. The machine gun was handy and hence was seized upon for trial as a possible means of reducing

the effectiveness of enemy artillery observation which had become alarmingly efficient. The results on all sides were far beyond all expectations, and from the first venture it was apparent that the right weapon had been found. It has been most truly said that flying was ruined when airplanes began to sprout guns and the air became part of the zone of hostilities. Scarcely had the art of flying advanced beyond its own earlier dangers before this new hazard was suddenly injected by the Fates and battles above the clouds, heretofore the dream of only the wildest romancer, became a stern reality, but, nevertheless, simply a part of the day's work for the military flier.

Like so many other unpleasant things, this method of fighting developed during the World War. No one knows just when or how it started. Certainly, the possibility of the use of machine guns on aircraft had been discussed before this time, and, indeed, in the early days of the War the French had several heavy planes equipped with them, although these machines were not of a type suitable for use at the front. The credit for the first trial of a machine gun in the air is, however, due to this country, for in June of 1912 a Lewis gun was successfully fired from a plane in flight, but nothing further was done to continue this development until there arose the necessity for action imposed by war.

The first recorded aerial combat occurred on the Eastern Front during the early days of the World War. Previous to this time military aircraft activity had been confined strictly to observation, partly because it was a novel as well as a new development, and partly, perhaps, because all concerned seemed to think that the aviator was taking his full share of risk by flying without molestation. Observation, however, meant direction of artillery fire, and the use of artillery was not by any means a new departure even though flying was. The result was that the artillery, through the aid of the new means of observation, developed at a bound to a vastly increased degree of effectiveness. Hence, the enemy aviator, calmly riding about overhead, uninterrupted in his occupation of guiding high-explosive to the points where it would do the most damage, became exceedingly unpopular. This dislike was manifested by the ground troops by taking pot-shots at the intruder with the weapons at hand, these being everything from a pistol to a battery. Such firing was, of course, not especially effective, for it became evident from the first that a plane in flight is a very elusive target. About the only result obtained was that the observers were forced to fly higher but, nevertheless, they continued to fly and to report with unabated effectiveness.

These conditions led to more or less of a coolness between opposing aviators who had heretofore looked upon each other rather as members of the same sporting fraternity who had no direct personal concern with the struggle beneath them. So one day when a Russian aviator chanced to meet an Austrian flying over the line he determined to wreck his adversary and thus prevent him securing information bound to result in damage to the Russian forces. Both were, of course, unarmed, and so the method adopted by the attacker was a variety of ramming, the idea being to upset the Austrian machine and still not become upset himself. The results were not entirely according to plan, for though the enemy plane was upset, it became fouled with the other and both crashed. This was the beginning, and from then on the air was considered as part of the zone of active military operations. Ramming having proved inadvisable, aviators gave each other a wide berth unless attacking, and carried pistols, rifles or shot-guns with which to snipe at each other as opportunity offered. Needless to say, such firing seldom resulted in any damage because of the difficulty of getting in a telling shot except by accident.

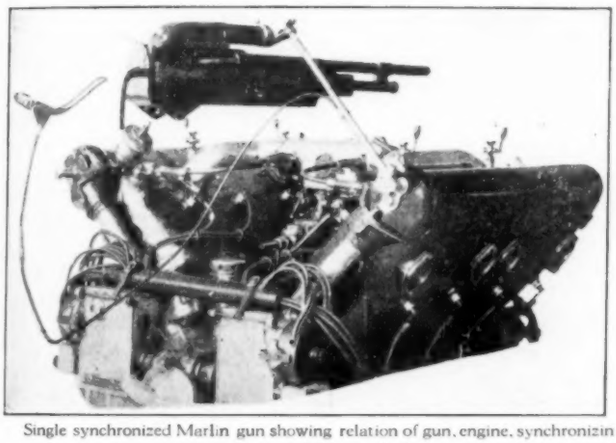
Meanwhile, the work of observation went merrily on, practically without interruption and with constantly increasing effectiveness, heedless of the—no one knows how many—councils and consultations called in the frantic endeavor to devise some means of coping with the winged menace which might, perhaps, at any time guide a shell into the very midst of any of these emergency conferences on ways and means. It was alarmingly evident that something had to be done, but for a time the question of what to do and how, baffled all efforts to devise a plan of action. And then, on the principle of fighting fire with fire, some unknown enterprising soul provided his plane with a machine gun, whether by order of higher authority or on his own initiative remains a mystery, as does even the identity of the belligerent first making the new use of this weapon which had proved so effective on the ground.

It was, of course, impossible to keep this application of the machine gun a secret, and so within a very short time all combatants were using them and the race in employing them most effectively was on. It goes without saying that the first attempts in this direction were crude, consisting, as they did, of only makeshift arrangements to carry and fire any existing machine guns available. The supply of guns was limited, too, and urgently in demand for use by the ground troops, so that as a result the ones more or less grudgingly released for aircraft were in some instances scarcely serviceable.

Lewis machine guns built for trench use were probably the first ones to be impressed in this new service. At any rate, they were the first ones to be employed by the Allied Forces, and they were mounted in two-seater planes for the use of the observers. These guns were chosen mainly because they were obtainable, but also for the reason that they were of a compact, portable type, fairly light in weight, and their construction was such as to give some promise of successful application to aircraft use. No better choice could have been made, for the Lewis gun still remains the observer's weapon in the French and British services, as well as our own.

Now that the arming of planes had become an accepted fact, it was evident at once that in ærial fighting speed played a very important part in the procedure of attacking successfully and getting away safely. The two-seater planes were not especially fast, but single-seater scout-planes, able to travel at high speed, were in use, and so the arming of these planes was the next step. Now, the pilot of an airplane is a very busy individual, and the project of adding to his already numerous duties those of a machine gunner naturally involved certain difficulties. It was obviously impossible to expect a pilot to aim and fire a machine gun in the usual way, and so the scheme of mounting the gun rigidly so that it pointed straight ahead in the direction of flight was hit upon. This provided for aiming by steering straight for the target and firing was arranged for by mounting a trigger on the control stick. The propeller, however, presented serious difficulties. These fast scout-planes were (and still are) of the tractor type, in which the engine and propeller are directly in front of the pilot. Hence, in order to avoid shooting the propeller off it was necessary to mount the gun so that it would fire outside the field swept by it. The only location found practicable for such a mount was on the upper wing of biplane machines, directly over the pilot's head, and conse-

quently this arrangement came to be known as upper plane mounting. Again, the Lewis gun was used, probably because it was the only one available, but it so happened that this gun was better suited for such use than any other. It was still found, however, that even though this system was practicable it still had serious disadvantages. First of these was that the amount of firing which could be done during one flight was limited, under the best conditions, to the capacity of one magazine (forty-seven rounds). The pilot could not reach the gun to reload or to correct stoppages which were by no means of rare occurrence, and so was obliged to either run for home as soon as his gun stopped as the result of either of these causes, or risk the destruction of both the plane and himself by remaining with his fighting equipment out of action. Tactical considerations soon brought forth regulations requiring aviators to abandon their missions and return with all haste when no longer able to fight, and these conditions led to insistent demand for more firing capacity. Another objection to this system of mounting, however, precluded improvement by the simple expedient of adding more guns.

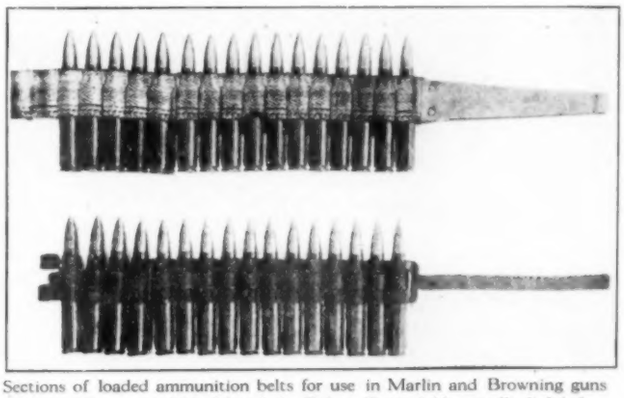


Single synchronized Marlin gun showing relation of gun, engine, synchronizin gear and control for use of pilot

This was the reduction in flying speed due to the added air resistance offered by the gun and its mount. Speed and capacity for maneuvering readily had even then been established as vital requisites of a fighting plane, and so this system of gun installation offered nothing in the way of possibilities for increased armament.

This clashing of conflicting requirements led to a new scheme, that of employing the usual upper plane gun and, in addition, a second gun mounted so as to fire straight ahead, but located on the cowling of the plane just in front of the pilot. This gun was to be held as a sort of emergency weapon because when using it good luck alone prevented the propeller being shot away, since its line of fire came well within the propeller field. But developments soon indicated that every combat was considered an emergency —not without reason, considering the nature of such encounters—and it became customary for the pilot to promptly open fire with both guns when firing at all, preferring the risk of losing his propeller rather than depending on half-way measures in attack. Another reason for liberal use of the added gun was that this method of mounting permitted the use of a belt-fed gun, with a much larger ammunition supply than was possible with the Lewis aloft. In almost any sort of a fight, the top plane gun would be speedily emptied, and the aviator might still have to combat half a dozen enemies before his flight ended, so it is not difficult to see how the extra gun came in for considerably more action than had been intended for it. Some planes, indeed, were equipped with only the lower gun. The makeshift nature of this arrangement was evidenced by the destruction of propellers resulting from nearly every combat and the consequent necessity in every such case for forced landing of the crippled ship. A propeller blade is ordinarily made unsafe by six or eight shots through it, but occasionally as many as twelve hits may occur without rupture. One propeller blade lost during this period by Captain Guynemer was found to have twenty-two holes in it at the time it broke.

This condition of affairs led next to an attempt to armor the blades so as to deflect the bullets striking them. But as the velocity and energy of such bullets are very great, the shields used had to be fairly heavy and carefully shaped so that the bullets would glance from them to one side or the other. Because of their weight, the shields had to be carefully balanced and braced substantially from the propeller shaft, and when all this was done it was found that the speed of the airplane had been seriously reduced, thus completing the circle of difficulties which began in the endeavor to increase scout-plane armament beyond the original top plane gun stage.



Sections of loaded ammunition belts for use in Marlin and Browning guns
Above: Non-expendable fabric belt Below: Expendable metallic link belt

Then, when the problem seemed hopeless so far as any satisfactory solution was concerned a truly sensational improvement was evolved, giving the pilot a gun installation based on sound mechanical principles. The fixed gun on the cowling was still used, but instead of being allowed to shoot wild through the propeller, was provided with a controlling mechanism operated by the engine to prevent firing when the propeller blade crossed the line of fire. This device is called a synchronizing gear, and guns so used are called synchronized guns. The new arrangement at once superseded the former systems for use of fixed guns and—because all guns do not adapt themselves well to synchronized fire—marked off more clearly than before the division of aircraft guns into two classes; namely, those used by the pilot and those for the observer, or as they are commonly termed, synchronized and flexible.

The details of the synchronizing gear are not important, but for the benefit of the mechanically curious it may be stated that an exact parallel exists in the valve action of an ordinary gas engine. Consider the valve as the gun trigger and the analogy is complete, except that it includes no means for throwing the mechanism in and out of operation.

The inventor of the synchronizing gear is unknown, but by some the credit for this development is given to Roland

Garros. In any case, it is certain that he was one of the first to make use of this idea, although it was at once discovered and adopted by the Germans who were, for a time, able to make more extended use of it than either the French or British. Its use is now established as an essential feature of plane armament and various forms of gears have been developed and manufactured.

After the introduction of the synchronizing gear the gun equipment of planes became more standardized and the requirements for these guns crystallized as their tactical use developed. The Lewis gun, however, continued to be the universal observer's weapon, so far as the Allied forces were concerned, and the Vickers gun was standardized for synchronized fire. Some modifications were of course made in the design of each gun to better fit it for aircraft service, the principal ones being the elimination of cooling apparatus and reduction in weight whenever possible. The capacity of the Lewis magazine was increased to ninety-seven rounds, improved turret mounts were designed and later the use of two guns mounted side by side and arranged to fire together was adopted in order to secure a greater volume of fire. Special sights were developed for both types of guns. Twin synchronized guns were found to be much more satisfactory than the single gun installation, and their use in pursuit planes, and in two-seater observation planes when the gun supply permitted, became general.

Some difficulty in using the usual fabric ammunition belt for the Vickers gun was experienced, due to the necessity for storing the empty end of the belt as firing progressed. This was remedied by the adoption of a metallic link belt, one link of which, as each cartridge is extracted and fed into the gun, falls apart from the rest of the belt and so may be easily disposed of by being carried overboard through a chute provided for this purpose. Various other improvements, both in the guns themselves and in the mounting arrangements devised for them were developed, but these were of a comparatively minor nature, for by this time the main principles had been well established. All planes were armed, either for attack or defense, or both, depending on the tactical use for which they were to be employed, and the armament equipment first considered rather incidental had gained in importance till it demanded attention equal to that given to the vital features of airplane construction. And this was all before the United States entered the war. Less than two years had elapsed since the first ærial combat, but even in this short time aircraft fighting had become an accepted and vitally important development of warfare. With this for a beginning, who will venture to say what the future battles among the clouds may be?

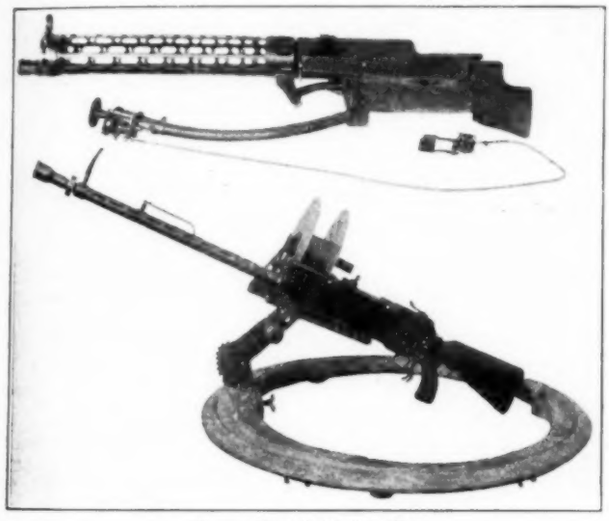
And now, perhaps a word as to German activities in this new development of fighting is in order. We naturally expect the German to participate with gusto in any scheme to add to the unpleasantness of war, and in this case he ran true to form. He also proceeded along established Teutonic lines by adopting at once equipment that was reasonably good and thenceforth not attempting to develop it much further, but bending every effort to make the greatest possible use of it. For his synchronized gun he took his portable Maxim field gun, and used it to the exclusion of all others. The Parabellum, which is Maxim in principle, was adopted for flexible use even though it is of the belt-fed type. These guns were used in much the same way as corresponding ones in the Allied forces, except that fabric belts were used almost exclusively instead of the metallic link type, and little attempt was made to increase their natural rates of fire. Liberal and indiscriminate use of the various kinds of special aircraft ammunition—tracer, armor-piercing, and incendiary—which had been developed by this time, together with that of exclusive type when opportunity offered, perhaps offset the comparatively slow firing rate of the guns employed.

When this country declared war we had neither airplanes nor armament for them, and so plans were at once made for production of both. Vickers and Lewis guns, both for use on the ground, were being produced in this country, the latter, however, at that time for the British Government. The insistent cry from abroad was for manufacture of these two guns to the exclusion of all others, as they had been proved in combat and could be readily adapted to aircraft use. In the case of the Lewis gun this was done. The British orders were soon completed and then as rapidly as possible production of aircraft type guns for our own forces was begun and this was continued until the Armistice. Production of the Vickers gun was also maintained, and as soon as possible was diverted to guns of the aircraft type. It soon became apparent, however, that more guns for synchronized use would have to be produced. No other sources of early production of the Vickers gun were available, and so it was decided to begin production of the Marlin, a new gun developed from the old Colt ground-type machine gun. Several thousand of these were turned out and many American planes at the Front were armed with them. The American pilot fought with either Vickers or Marlin guns, and his observer with the Lewis. Before the Armistice production of the Browning Aircraft Gun, a modification of the famous Browning ground-type machine gun had been started, but none of these were received at the Front before the cessation of hostilities.

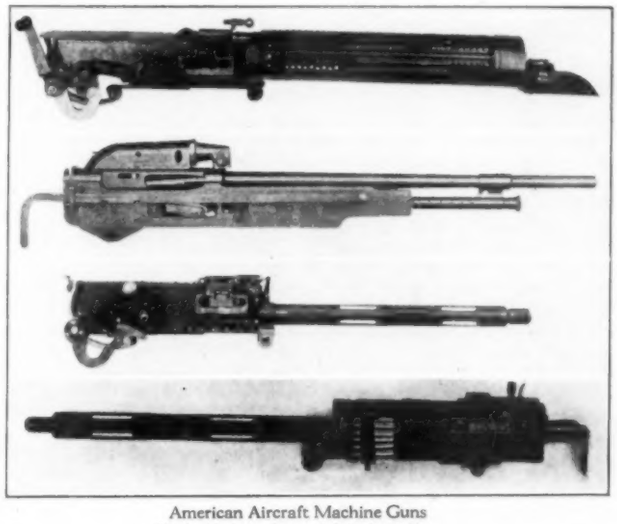
The question as to which is the best machine gun is frequently asked, although most often by those who vaguely ascribe to this weapon but two main characteristics—one being that it pours forth a stream of bullets at a terrific rate (the more terrific the better) and the other that at the most inopportune moment it always jams, whatever that may mean. There is no best machine gun, aircraft or otherwise, any more than there is a best automobile. It is impossible to compare guns in general, but when the use to which they are to be put is specified there is some basis for discussion. Thus in case of flexible guns there is a best one. Beyond question this is, because there is only one, the Lewis. Tactical developments of the war seemed to divide the requirements for flexible and synchronized guns very sharply, and in all the Allied forces the Lewis was adopted for flexible use. Its characteristics of magazine feeding, compact construction, and light weight fitted it admirably for this service, but as a synchronized gun it is worthless. The Vickers was the pioneer synchronized gun, and is still one of the best. Both of the other types developed in this country have their advantages, however, or else have their drawbacks, and these deficiencies can, in each case, be traced back to the fact that these guns are all adaptations of similar guns built originally for ground use. Satisfactory fulfillment of the requirements for aircraft weapons can be obtained only by original design based squarely on these requirements, which, by the way, are now very definitely and completely known. Makeshift adaptations, no matter how clever, can never give the best results, and while they cannot be avoided under war conditions, they should not be permitted to occupy an important place in peace-time development.

Even though the synchronizing gear brought about the

division of aircraft guns into two classes, experience has shown that there are certain general requirements which they must all meet if they are to give satisfactory service. The first of these is positive and dependable operation. Failure of the gun in a critical moment in combat is almost certain to be fatal in results to both plane and crew, hence the weapons used must respond instantly and certainly when called upon. They must do this, moreover, in spite of many adverse conditions such as extreme cold, moisture, vibration and maneuvering of the plane, and aiming, which may place them in any position except the normal horizontal one, and unintentional mistreatment by the gunner in the excitement of combat. Another very important feature is speed in firing. On the ground a firing rate of more than four or five hundred shots per minute is not considered especially useful, but in the air conditions of combat are such that a rate twice as high is a distinct advantage. Even higher rates might be desirable, but opposed to them are considerations of reliable operation, which is always sacrificed in obtaining excessive speed, and ammunition supply which is necessarily limited. A speed range of from 900 to 1200 rounds per minute is probably most satisfactory, as a compromise between these conflicting requirements. These are the two most important features. Other subsidiary ones, such as light weight, compactness, durability, simplicity of construction, and ease of maintenance and repair, are obvious and need no comment, applying as they do to all classes of automatic arms.



German Aircraft Machine Guns
Above: Maxim (Spandau)
Below: Parabellum Flexible Aircraft Machine Gun Mount
The reel on the right hand side carries the fabric ammunition belt



American Aircraft Machine Guns
Early Vickers Aircraft Machine Gun
Marlin Aircraft Machine Gun
Latest developement of Vickers Aircraft Machine Gun, Model 1919
Browning Aircraft Machine Gun

There are various special requirements applying to each of the two classes of guns, but these, except the ones concerning the feeding and firing mechanisms are incidental. A magazine system of feeding seems necessary for the flexible gun, while the synchronized gun is fed by belt in order to obtain greater ammunition capacity. Numerous attempts to use a belt-fed gun flexibly have been made, and indeed the Germans used a gun of this style—the Parabellum—as their standard flexible weapon. The difficulties in this connection are mostly those of mounting and, although so far nothing superior to the Lewis gun has been developed for our service, it is very likely that in time arrangements for using the standard synchronized gun in this way will be perfected. The advantages of such a system, in which only one style of gun would be manufactured and maintained in service, are obvious and explain the continued efforts in this direction.

Synchronized guns must be equipped with firing mechanisms which act very quickly, whereas flexible guns are not limited in this respect. There is no objection, however, to the use of the quick-acting firing mechanism by the flexible gun, and so the project of reconciling the design of these two types is not adversely affected by this consideration. It seems evident, however, that progress in this direction must be made by adapting improved designs of synchronized guns to flexible use rather than the reverse.

Then, what of the future aircraft machine gun? This discussion is not intended to include specifications for the ideal weapon, but certain outstanding features of the tendency of development are clear enough to warrant consideration. The provision of all the desirable characteristics described above will not in itself produce a fully developed weapon. The gun must be built for its place in the plane as well, and especially in the case of synchronized guns there is a great deal of room for improvement in this direction. These guns are now invariably used in pairs, and in order to provide a workmanlike installation it is extremely desirable to have all parts of the auxiliary equipment of mount, ammunition boxes, feeding and ejection chutes and synchronizing gear arranged symmetrically with respect to the axis of the machine. The most important point in providing for this symmetrical mounting is provision of means for selective right or left hand feeding of the ammunition belt. Ejection of the empty belt links will naturally be free from the side opposite to that of the belt entry, and ejection will probably be from the bottom. This feature has already been obtained in Vickers guns, and is of such value that no new design of this type of weapon in the usual calibers can be considered complete without it. Other similar features, such as corresponding provision for selective right or left hand location of the synchronizing mechanism and operating handle go naturally with the alternate feeding arrangement and round out the idea of symmetry for the whole installation. Accessibility of the working parts, with consideration of the fact that the pilot is located behind and between the guns is also very important. The pilot must do many things at once and at best can never work on his guns with more

than one hand and still keep control of his machine, hence the necessity for making this one-hand first-aid attention as easy and convenient as possible for the only fighter who must win or lose alone. Many other advantageous features might be mentioned, but these are the most important ones, and when these are provided the difficult part of the problem will be solved.

Up to the present, aircraft machine guns have been built in service small arms calibers only, but there is every indication that heavier calibers will be needed for attack of armored planes. Such weapons would have enabled Major Lufberry to combat successfully the "flying tank" that shot him down in the face of fire that no plane had ever before been able to endure. The development of armor for aircraft demands the production of a weapon which the armor cannot withstand, but in this competition the advantage is with the gun, because of the great weight of armor required for even partial protection. Designs of such a weapon capable of piercing over an inch of armor have been developed and tested, although thus far none have been mounted in an airplane. In these designs the principles of the most successful weapons of standard caliber have been followed, so that the result is in reality a super-machine gun. If the next war is to be decided in the air it is not beyond the bounds of possibility that the decision may depend on the use of this newest and hardest hitting of all the weapons that have been made to fly.

A German Recuperator

By

JOHN B. ROSE*
Member A. O. A.

Those members of the Association who were engaged during the war in the production of any one of the several types of recuperator mechanisms for artillery gun carriages will recall that the manufacture of these mechanisms was found laborious and difficult. The recuperators were usually made by boring several cylinders out of a single large forging, and as these cylinders required a very fine and exact finish, manufacture was felt by all those concerned to be extremely difficult, and perhaps unnecessarily so.

It is therefore with considerable interest that examination of types of German recuperators has been watched. Captured matériial including practically every type in use by the Germans has been brought to the United States, and it has been possible to examine and study the mechanisms in great detail, this being done with a view to taking advantage of any good features which may be uncovered. One of these mechanisms which has been carefully examined is that of the 150 mm. German Howitzer Carriage of the latest type used during the World War. This howitzer and carriage conforms in general characteristics to the 155 mm. howitzer matériel of a foreign type which was used by the United States during the war.

Perhaps the first question which occurs to the inquirer is whether the German recuperator is better than that which we use ourselves, and the admission that this question cannot be answered positively by yes or no will be readily understood by the engineer. We can easily perceive that in a given class of automobiles, while the various machines may be widely different in their characteristics and features, it is not possibe to say without some qualification that machine A is better than B or C. The situation is the same as regards a comparison of recuperator mechanisms. The most that can be said is that the recuperator which forms the subject of this article appears quite on a par with others known to the Department, and its design has apparently been worked out with great care. In some of its features the mechanism is reduced to a simpler form than some of those used in the War, but these simplifications have sometimes resulted in compromises with other conditions which have introduced offsetting complications.

It is further concluded that taking various sub-assemblies of the mechanism separately, the recuperator does not present anything new or novel; however, in the combination of these sub-assemblies the resulting recuperator possesses characteristics which are unlike others in use, known to the Department. Before drawing further generalizations it will perhaps be better to consider more specifically some of the details.

It may be noted parenthetically that the term recuperator has grown during the last few years to designate the mechanism which restrains the movement of a gun as it is forced backward in recoil, due to the force of the explosion, and then returns the gun to its initial position on the carriage. Accurately speaking, the term covers only that part of the mechanism which performs the second function.

The drawing forming a part of this article represents a longitudinal section taken in a central vertical plane through the mechanism. The reader should understand that the gun is attached by a lug at the breech end to the outside cylinder A by means of the threads T at the rear of this cylinder. The recoil rod B and the recuperator rod C are locked at the front ends to the cradle, which is a non-recoiling part of the carriage. All of the cylinders and packings, therefore, move with the gun, the whole recoiling mass being supported in translation on the guides L and M, shown in the end view, which move in corresponding ways on the cradle. It will be noted that with the exception of the valves necessary for filling and draining purposes and the packing around the recoil and recuperator rods, the outer cylinder forms a complete seal for the entire system, since the joint D, which is made of soft copper, prevents any escape of air at that point.

We will first consider the recoil part of the mechanism, since this is entirely separate from the recuperation or counter-recoil side. As the recoiling parts move to the rear, the oil which fills the recoil cylinder to the front of the piston has two avenues of escape. The first is through the ports, as shown at E. The oil forces the valve F from its seat in the piston head, and passing through this valve enters the hollow piston rod. The cavity in the piston rod is thus filled so that upon counter-recoil of the gun the buffer G traps the oil in the rod as in a dash pot. As the valve F is a one-way valve, the oil in the piston rod cavity must escape through the clearance between the buffer rod and the sleeve H. This clearance is so regulated that the resistance offered will insure absorption of the excess energy of the recuperator side and prevent the gun from returning too violently to its firing position.

The second avenue of escape of the oil is through the ports in the piston head. It is desirable that the resistance to recoil should be such that at no time a high peak occurs in the pressure curve, and also such that it conforms as nearly as possible to the changing stability of the carriage during recoil. In order to accomplish this, the ports in the piston head must be made variable. In the section view CC, it will be noted that two grooves are cut in the walls of the recoil cylinder. These grooves are cut on a spiral. The bronze sleeve I forms a part of the piston head and acts as a guide for the piston head in the cylinder. The part J, however, has two splines on it which move in the spiral grooves, and thus rotate J as the parts recoil. As I passes over the grooves in the cylinder the oil flows through these grooves past I, thence through ports which are cut in the part J, thence through ports cut in the part K. The relation of the ports in J and K is varied by the rotation of J, and thus the desired variale pressure in the cylinder is secured.

The device above described provides a means of securing the desired curve of oil pressure plotted as a function of recoil. In view of the fact, however, that we are firing at elevations of from zero to 40 degrees, it is necessary to provide a second adjustmnt so that this curve can be varied for elevation. This is done by rotating the piston rod as the gun elevates, so that for each elevation above 20 degrees the initial relation between the ports in J and K is different. The initial relation being thus fixed as most suitable, the variations in pressure during recoil is secure as above described.

The above described system for controlling recoil is not novel and has been known to the Department for a number of years. The

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details of construction are, however, naturally to some extent peculiar to the mechanism being described.

The oil in the recoil cylinder is normally under atmospheric pressure, and the packing around the rod need only be sufficient to retain this oil under the temporary high pressure created during recoil. The recoil cylinder does not require a polished finish, but it should be smooth and without noticeable tool marks.

We will now consider that part of the mechanism which stores the energy for returning the gun to its firing position at all elevations. The recuperator piston N moves during recoil in the polished cylinder O, forcing the oil in front of it through a port shown at P. The oil then passes along the short cylinder shown with the diameter 1.875 marked R in the ower part of the illustration. This cylinder is open at its rear end, which remains at all elevations submerged in the body of oil which is contained within the cylinder A, shown in section CC. This oil surrounds the three cylinders contained within A, but it does not completely fill the space. The forward portion of the space contains air, which being compressed between the oil and the front end of cylinder A, stores up the energy for returning the gun; that is, as soon as the end of recoil is reached, the compressed air forces the oil back through the cylinder R, through the port P, and against the piston end, thus returning the parts to their initial relation.

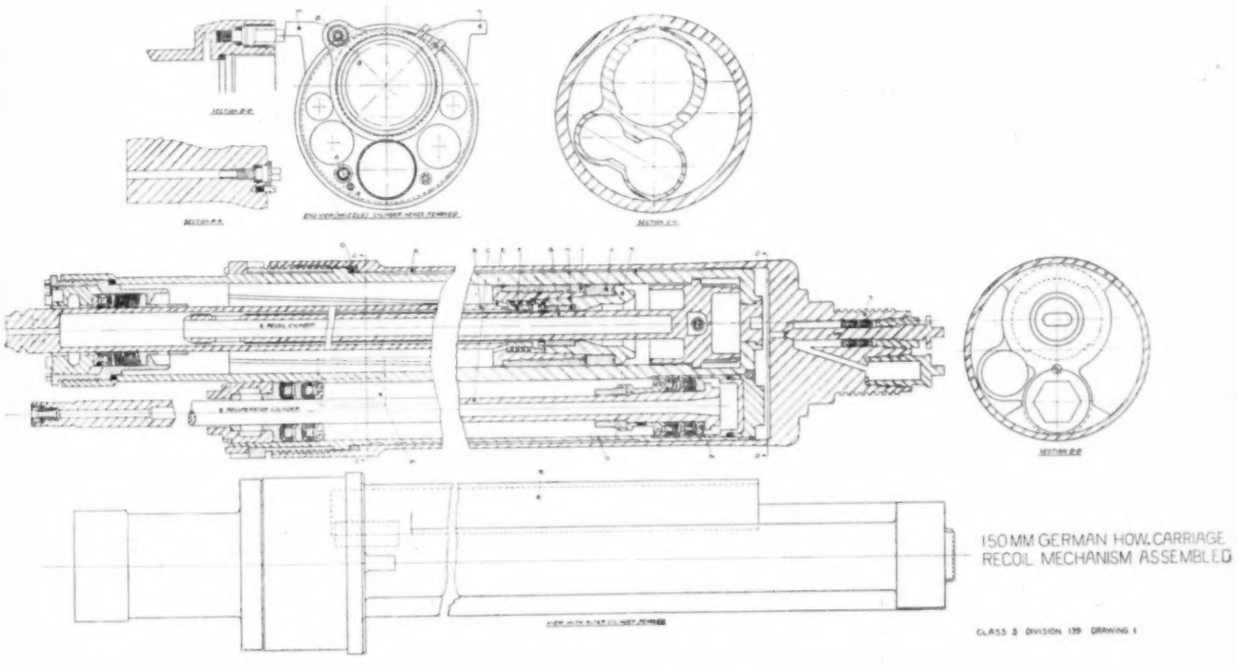
It will be noted that the oil forms a liquid seal against entrance of air to R, and there is no point of escape for the air except through the joint at D, which, being fixed, can be easily made perfect.

This system of recuperation in itself does not possess novel features, although the details of its execution are peculiar in some respects to the design. The combination, however, of this system of recuperation with the recoil system described is somewhat novel.

It will be noted that the recuperator cylinder must be highly finished, since the oil acting on the packing of the piston end is under an initial pressure not as yet accurately determined, but probably approximating 500 pounds per square inch. The method of packing the piston, however, is thought to be good, although by no means novel. It will be noted that the recuperator piston rod is made hollow with a valve at the front end. This valve is to allow the escape of oil which might seep past the piston end and prevent by its accumulation full counter-recoil.

Manufacture of the mechanism above described is by no means simple. The large outer cylinder A must be constructed out of homogeneous steel of good quality, and as designed requires removal of a large amount of metal; in fact, the cylinder as finished very evidently represents but a small fraction of the original forging out of which machined. It would be possible as an alternative to forge the cylinder hollow on a shell press, but this in itsef would be expensive. The three cylinders contained within A also require removal of a large amount of metal in their manufacture, and a high finish in the cylinder O. In order to secure the necessary lightness, these cylinders must be formed on the outside as well as inside, requiring the use of planers or heavy milling cutters. The system of packing piston cylinder heads appears to be good, but as above stated, not novel.

The liquid above referred to as oil has upon analysis been determined to be an aqueous solution of sodium lactate of about 45 per cent strength. The use of this fluid gives an interesting sidelight on the use of substitutes to which the Germans were driven. It is of course not known definitely whether the use of this fluid was the result of choice or of necessity. However, as lactic acid and various lactates are the by-products of various industries, such as woolen dyeing, tanning, fermentation of organic materials, etc., it would appear that it was used on account of its availability. The presence of small amounts of iron and copper have been noted in the samples analyzed. This may be due either to their being present in the by-product or due to chemical action on the parts of the mechanism. It will be necessary to establish this before the merits of the liquid can be fully determined. As far as known, however, its use has been satisfactory, and as it has a low cold test, it possesses some advantage over oil and glycerine in common use. Furthermore, the recuperator mechanisms of the type described herein commonly use glycerine, which is quite expensive at all times, and especially so in war time. The use of sodium lactate is, therefore, as a measure of economy also desirable.



While there are a number of interesting minor features which might be discussed at some length, it is thought that a discussion of these without comparison in each case with corresponding features in other designs would not afford information sufficient to permit any reliable conclusions to be drawn by the reader, and the above discussion merely presents the general characteristics of the mechanism. The analysis which has been made of these recuperators is, however, sufficient to indicate quite clearly that the advance in the art of design and manufacture reached about the same stage on both sides during the war. It does not seem that considerable improvement in these mechanisms can be made, unless some radical change is effectd. On the other hand, the mechanisms as now manufactured certainly present so many difficult features that improvement in the direction of simplifications is highly desirable.

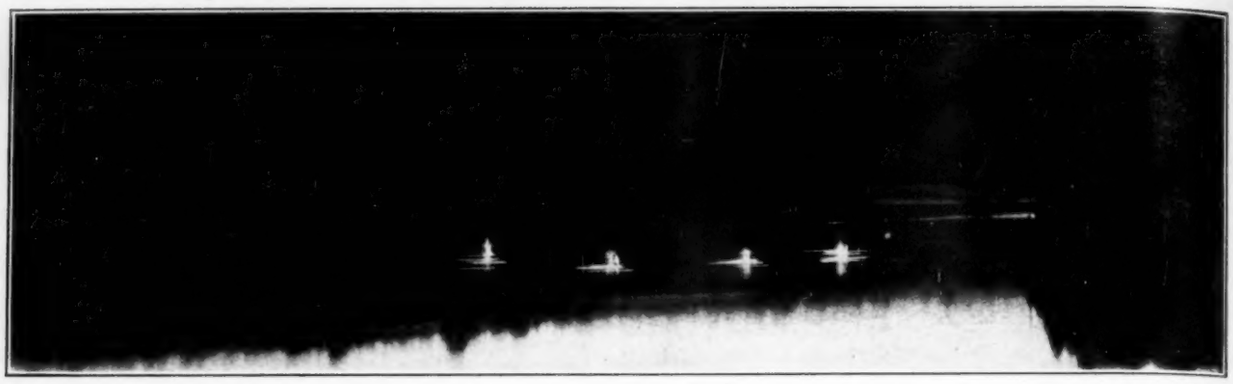


Fig 1 Parallel Machine Gun Dispersion, Four Brownings. Range 1100 yards

Long Range Small Arms Firing

PART I

Establishment of Small Arms Experimental Ranges at Borden Brook Reservoir, Mass., and at Miami and Daytona, Florida

By

GLENN P. WILHELM
Member A. O. A.

[Co'onel Wilhelm was in direct charge of small arms experimental firings by the Ordnance Department during the World War. In this work, he made extensive use of the photographic art for verifying ballistic data previously based very largely on mathematical computation, as well as for pioneer work at long ranges.
By permission of the Chief of Staff, U. S. Army, the results of these painstaking researches are being published in this and succeeding numbers, not merely as interesting information concerning progress made in small arms ammunition, but as having a real value from the standpoint of Army morale, in educating the combatant forces in the scientific methods utilized to increase the effectiveness of that indispensable tool of war—the infantry rifle.—ED.]

During the World War the Ordnance Department instituted a series of small arms firings chiefly at long range, on a scale and at ranges which had never before been attempted. The experiments themselves are of such interest to the service and the results of these firings will eventually have such far-reaching consequences, that it is intended to publish in a series of articles the manner in which the tests were conducted and the information obtained.

The scope of the firings can be realized from the following facts:

1st. Three different experimental ranges were used, as widely separated in location as Massachusetts and Florida.

2d. Tests were conducted lasting over a period of nearly two years, *i. e.*, from July 1st, 1918, to May 25th, 1920.

3d. Several hundred thousand dollars were expended, and the tests required a personnel averaging about 75 officers, enlisted men and civilians.

4th. Total number of machine guns used amounted to over a hundred, and the total amount of ammunition expended was more than a million rounds. This does not include the large number of guns and the large quantity of ammunition representing special types as well as the standard military weapons in use by the great powers, nor the sporting arms of commercial companies.

5th. Firing was held with small arms up to the maximum ranges of the ammunition. Special experimental .30-caliber bullets were successfully fired and recovered at ranges as great as 5,000 meters (5,500 yards). Bullets were also recovered that had been fired vertically upward.

It is proposed to discuss the following subjects in these articles: Part I, Establishment of Small Arms Experimental Ranges at Borden Brook Reservoir, Mass., and at Miami and Daytona, Florida. Part II, The Determination of Ballistic Data by Actual Firing. Part III, Machine Gun Dispersion. Part IV, Effect of Barrel Erosion on Machine Gun Dispersion. Part V, Boat Tail Bullets. Part VI, Vertical Firing. Part VII, Miscellaneous Data.

Small Arms Experimental Range, Borden Brook Reservoir, Mass.

One of the first problems confronting the Ordnance Department at the participation of the United States in the World War was the preparation of small arms fire control tables, particularly with reference to machine guns. Inasmuch as the standard type of small arms ammunition, *viz*: U. S. Ammunition, Caliber .30, Model of 1906, with a bullet weighing but 150 grains and having a muzzle velocity of 2,700 feet per second, was originally designed and adopted for the purpose of giving a flat trajectory over rifle battle ranges, but little was known regarding this bullet's performance beyond 1,000 to 1,200 yards range.

Ballistic calculations and computations, based upon the efficiency of the 150 grain, .30-caliber bullet at short ranges, have long been published in Ordnance Pamphlet No. 1923, called "Description and Rules for the Management of the United States Rifle, Caliber .30, Model of 1903." The tables contained in this book were carefully determined by actual firing up to a range of 1,000 yards, which at that time was considered to be the maximum

range at which accurate aimed rifle fire would be effectively used.

For greater ranges calculations were made using standard ballistic functions, but using the data already obtained by actual firing up to 1,000 yards. As these calculations utilized well-known ballistic functions which had been established by experiments with all types of projectiles, and inasmuch as the same methods were in universal use by all the great powers no one entertained a doubt as to the correctness of the tables at long ranges. To have believed otherwise would have been contrary to the theories established by some of the world's greatest ballisticians, both

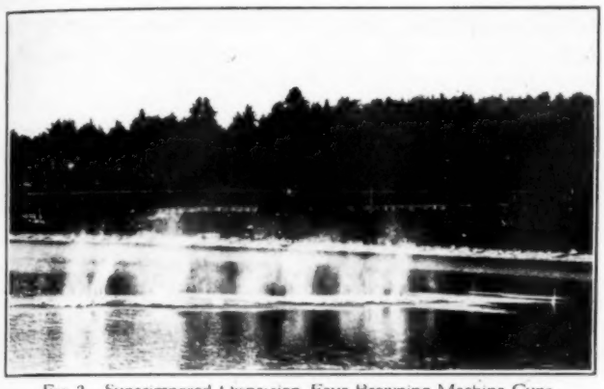


Fig. 2. Superimposed Dispersion. Four Browning Machine Guns Range 1100 yards

American and foreign, whose works had all the additional weight and authority which the lapse of time was able to give them.

It was therefore decided at the outbreak of the war to base the first issue of fire control tables upon the tables contained in the handbook of the rifle. On account of the adoption of the metric system by the A. E. F., it was necessary to laboriously change all fire control tables into the metric system, which, however, could not be done by merely giving the metric equivalent.

Upon completion of the metric fire control tables for .30-caliber ammunition, before issuing them to the service, firings were instituted for the purpose of verifying the figures. As the tables were universally known to be correct up to 1,000 yards, inasmuch as the National Matches and all other range firing by the Army had proven this, it was planned to conduct the major portion of the tests at ranges beyond 1,000 yards.

There immediately resulted the problem of what kind of target to use at such great ranges, because previous experience had revealed the difficulty of successfully firing at the usual form of vertical paper targets at ranges even as great as 1,200 yards.

As a preliminary some firing was done in June, 1918, at a vertical paper screen or target, 24 feet high and 60 feet wide. This target was located along the Connecticut River at Longmeadow, near Springfield, Mass., on the same site that the original firings were held through paper screens at the time of the adoption of the Sprinfigeld rifle and the present '06 bullet.

This range was 3,000 meters (3,300 yards) long, but it was soon found by actual experience that no reliable results could be obtained by this method at ranges exceeding about 1,300 meters (1,400 yards). One interesting fact was observed to the effect that the Browning Machine Gun, which was used in firing, required 30 meters more elevation on the rear sight than the graduations called for at 1,000 meters; and 150 meters more at 1,700 meters range, with correspondingly greater elevations at the intermediate ranges. Later firings showed that it requires 1,850 meters elevation to fire at a range of 1,700 meters, according to the rear sight, thus verifying these preliminary results.

In order to facilitate the work it was decided to secure a location where it would be possible to obtain the impact of bullets at the end of their flight, thus requiring merely the firing at a given elevation and deflection without regard for the nicety of trying to hit a given target. Inasmuch as this work was all being carried on by the Ballistic Section of the Small Arms and Ammunition Proving Ground at Springfield Armory, it was desirable to locate the range as near the Armory as possible. Moreover, in order to measure the impact of small arms bullets, it follows as a matter of course that the surface upon which the bullets are to fall must be smooth, as otherwise the impact will never be observed or found. Small arms bullets at long range make a very slight disturbance on any surface, and nothing is more futile than to fire modern high power small arms over ordinary terrain and expect to find evidence of where the bullet finally came to rest. In addition to requiring a smooth surface upon which the bullets must fall, it is also necessary to have this surface of considerable area; otherwise it will be difficult to hit.

Only two natural surfaces meet these requirements, viz, the smooth surface of a body of water or a smooth beach along the seashore. Securing a beach near Springfield Armory was out of the question, so that search was made of topographical maps for a lake or other body of water in the vicinity of Springfield, Mass., which would be suitable for firing.

There were a great many other elements entering into the problem, particularly with regard to the safety of the civilian population residing in the vicinity of the range. However, after a careful study, Borden Brook Reservoir was chosen as meeting more of the requirements of the

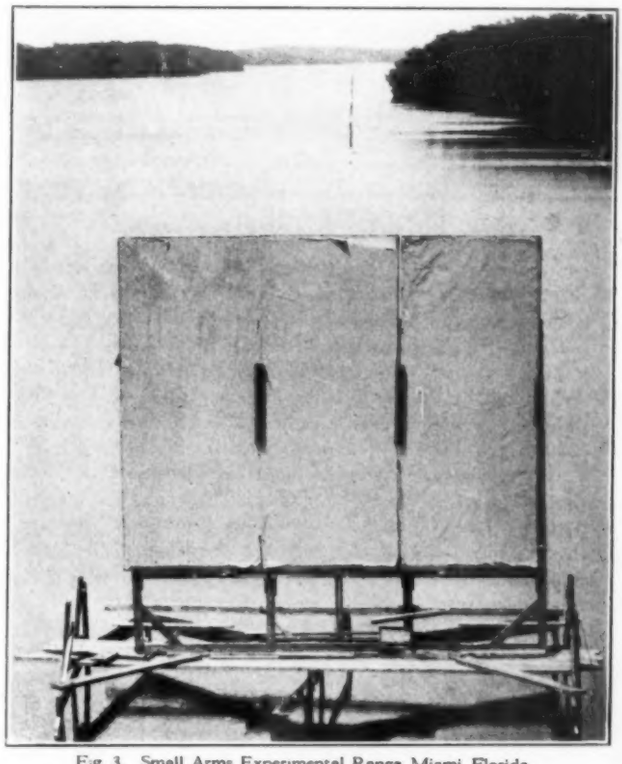


Fig. 3. Small Arms Experimental Range, Miami, Florida from Firing Point

ideal range than any other place. This reservoir is a beautiful sheet of water in the Berkshire Hills of Western Massachusetts, about 25 miles west of Springfield, formed by damming up various streams. The reservoir is one of the reserve water supplies, or storage basins, for the City of Springfield, and the use of this reservoir for the firing was very kindly authorized by the city officials.

The short range firing point permitted of firing being done at ranges from 600 to 1300 meters, with an auxiliary location allowing ranges up to 1600 meters (1,750 yards).

Another intermediate firing point was located so as to obtain ranges from 1600 to 2000 meters, while a long range firing point was located giving ranges from 2000 meters

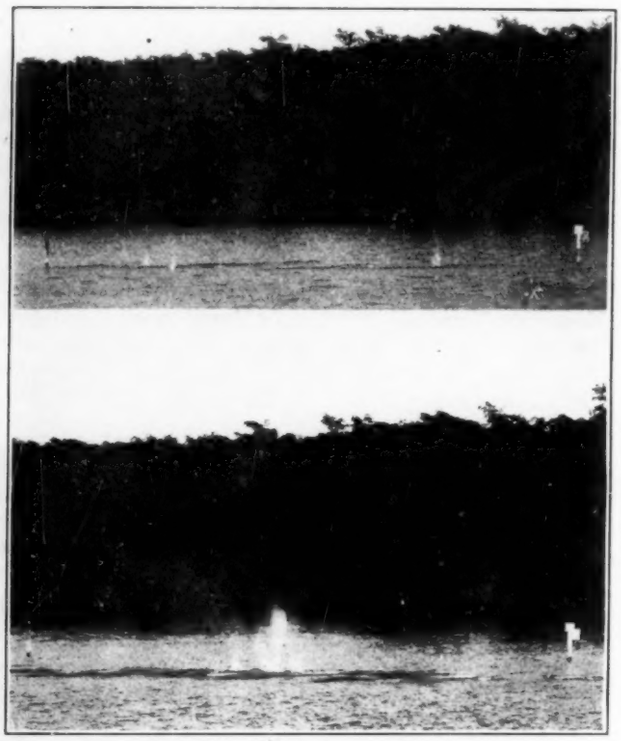


Fig. 4. Comparison of Splashes at 2200 yards range
Above: Browning Machine Gun Dispersion of Service Bullet
Below: Browning Machine Gun Dispersion of special Boat-Tailed Bullet
Service Bullet required 50% more elevation than Boat-Tailed Bullet at this range

(2,200 yards) to 2600 meters (2,850 yards), which was the maximum range possible.

In general, the method of firing at Borden Brook was as follows: All firing points were so situated as to allow the impact of the shots to be observed on the water by instruments located near the firing position. This necessitated firing down at an angle of from 7 degrees at the shortest ranges, to less than 2½ degrees at the longest ranges.

Ranges were determined by instruments from the gun to the impact of the shots. Also the elevation of the gun was recorded, as well as the deflection. The time of flight was determined by observation of the impact of the bullet. Measurements of wind and horizontal deviation of the bullet were also secured.

This article will not attempt to describe in detail the methods and refinements used in determining the various ballistic data, as this will be more fully covered in a later article.

Fig. 1 illustrates the impact in the water of the bullets of four Browning Machine Guns fired automatically and using service ammunition. The range is about 1000 meters (1,100 yards), the guns being in the rear and slightly to the right of the position of the photographer. The four guns have equal angles of departure and the beaten zones are parallel. The zones are about 25 yards apart, showing how narrow is the dispersion of each gun and the amount of space between zones not covered by fire.

Fig. No. 2 is similar to Fig. No. 1, except that the four beaten zones are superimposed and the view is from the right, the photographer being within 50 yards of the center of impact. In both Fig. No. 1 and No. 2 the guns are firing down into the water at an angle of about 3 degrees.

The result of the firings at Borden Brook was the accurate determination of tables of fire, including elevation, time of flight, etc., for the Model 1906 ammunition (service) at ranges beyond 1000 yards; the determination of beaten zones for the Browning and Vickers Machine Guns; the accuracy life of machine gun barrels fired under service conditions and worn out by erosion; the determination of angles of jump for machine guns; the effffect of wind on service ammunition at long range, and a vast amount of other valuable data.

Considerable information was obtained with regard to the penetration at long ranges of various types of small arms bullets and also data on the angle of fall at long ranges.

These firings lasted until October, 1918, and so important had this work become that a considerable amount of scientific equipment had gradually been assembled and the necessary trained personnel obtained to handle it.

In the meantime the A. E. F. were making insistent demands for the development of a more effective type of long range machine gun ammunition. Up until this time, and in some divisions much later, the American Army in France had been using the Hotchkiss Machine Gun and the French 8 Millimeter Lebel cartridge, with the "Balle D," a type of boat-tailed bullet weighing a little less than 200 grains. This bullet, on account of its great weight and excellent ballistic shape was capable of effective firing up to nearly 3500 meters (3,850 yards), and was the most effective type of long range machine gun bullet used by any army until the Germans, in the latter stages of the war, produced a somewhat similar long range bullet that was even superior to the "Balle D."

The U. S. Caliber .30, Model 1906 ammunition, with its 150 grain bullet, naturally was not adapted for such long range shooting, for which it was not originally intended, except in one particular—accuracy. Even at the greatest ranges the Borden Brook experiments showed that the density of the cone of dispersion of the Browning Machine Gun firing service ammunition was greater than that of any other type of ammunition used by any belligerent. However, its maximum effective range was only about 2500 meters (2,750 yards), and its maximum range about 3000 meters (3,300 yards).

As a result of the developments on the other side toward long range machine gun fire, the experiments at Borden Brook were directed to testing ammunition which had been designed by the Small Arms Division of the Ordnance Department and manufactured at Frankford Arsenal, for the purpose of obtaining a long range, effective machine gun ammunition.

Fire control tables, based on the Borden Brook firings, were issued to the service before any extended use had been made of American machine guns and ammunition on the other side. These tables were later amended by the Florida

firings, but the revisions made were mostly technical changes of a minor nature.

Insofar as rifle fire is concerned no changes in sights or fire control tables are necessary, because aimed rifle fire beyond 1,000 yards is rarely used in battle, and the error in the sights for several hundred yards beyond 1,000 yards is negligible.

This error can also be neglected in the case of the machine gun, because machine gun fire at ranges great enough to be affected by the error in the sight leaf is obtained by laying the gun by clinometer elevation, using the new fire control tables.

Climatic conditions at Borden Brook were unfavorable for firing later in the year than October, and it was necessary to close the range before the development of long range machine gun ammunition had been completed. The range was not closed, however, before some excellent photo-

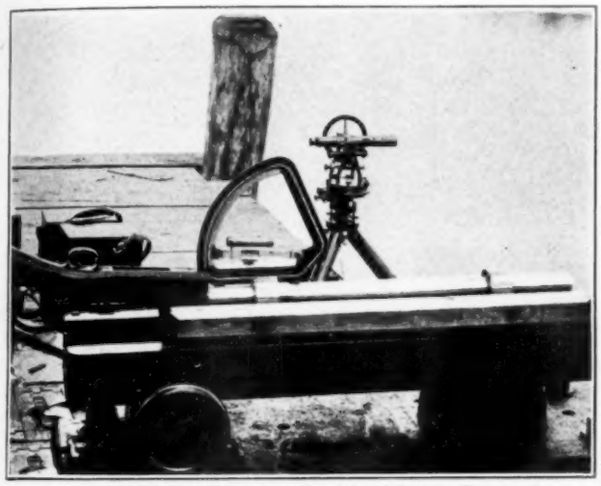


Fig. 5. "Mann Rest" fitted to Frankford Machine Rest used in Florida Firings

graphs of tracer ammunition were obtained by firing at night.

The closing of the Borden Brook range made necessary the establishment of a ballistic range where firing could be held throughout the winter. It was also desirable to obtain a location where even a greater range could be obtained than was possible at Borden Brook, in order that tests could be conducted with new and more effective types of small arms ammunition up to the very limits of the trajectory.

Moreover, the Borden Brook range had several serious disadvantages, one of which was inclined firing. That is, the firing, except in a few tests was always at an angle downward of from 3 to 7 degrees. Also the barometric conditions at Borden Brook were not ideal, as this place was at sufficient elevation above sea level to have average barometer readings of 28 to 29 inches, instead of a mean of about 30 inches, as is desirable.

Establishment of Small Arms Ballistic Station at Miami, Florida.

Therefore, in order to complete the experiments it was necessary to select a location in the south, and after a careful study a site was selected near Miami, Florida. The entire personnel and equipment used at Borden Brook were transferred to Miami, and the Small Arms Ballistic Station was established there in December, 1918.

The atmospheric and other conditions at this site were ideal. The range itself consisted of a narrow body of water about 200 yards wide and over 4,000 yards long, running north and south. The water was quite shallow and protected from winds by a dense grove of mangroves on each side. As a result the surface of the water usually resembled a mirror, thus allowing observation of impacts to the best advantage. The range was staked out and observation towers were located every 500 meters, so that ranges were obtained by direct observation, and not by instruments at the firing point as was done at Borden Brook.

Fig. No. 3 is a view of this range, which is at sea level, and shows the arrangement of the screen in the foreground, the line of range stakes disappearing in the distance, and the observation towers along the left. The screen is for the purpose of measuring the true elevation and deflection of the line of departure of the bullets, which measurement is necessary in addition to the elevation and deflection of the gun itself, as the bullet does not always leave in prolongation of the center line of bore.

At Miami tests of small arms and ammunition were con-

Fig. 6. Browning Machine Gun Dispersion on Sand. Range 1100 yards. Impact of each bullet marked by "spotter." Burst of 100 rounds. Length, 115 yards. Width, 3 yards.

tinued on a greater scale than before and an entirely new determination made of the data for service ammunition, which, however, checked remarkably close to the figures obtained at Borden Brook.

The facilities of this range were such that complete data under a given set of weather conditions could be obtained from a range of 200 yards up to 4,000 yards in the course of less than an hour. This includes the measurement of elevations, time of flight, wind effect, drift and angle of jump at all ranges.

The dispersion of a Browning Machine Gun, firing at a maintained rate of fire of 500 rounds per minute including all reloadings, malfunctions, stoppages, etc., could be measured at any range up to the limit of the trajectory from the beginning of the test until the barrel was worn out.

Fig. No. 4 shows the impact of service ammunition as fired from the Browning Machine Gun. The range stake in the right is at 2,000 meters range, the next stake to the left being at 2025 meters range. The impacts of the three shots are at about 2005, 2018 and 2020 meters respectively. (Note the small size of the splashes, showing that the bullet has lost most of its velocity and energy.)

The Miami firings resulted in finding a .30-caliber experimental boat-tailed bullet that had an effective range of 5000 meters (5,500 yards). Fig. No. 4 also shows the impact of this bullet as fired automatically from the Browning Machine Gun at a range of 2000 meters. (Compare the size of splashes in this photograph to those of Service am-

munition shown at the same range.) The elevation required to fire the boat-tailed bullet 2000 meters was but two-thirds that required to obtain the same range with the service bullet.

It was during these first Miami firings, which lasted from December, 1918, to June, 1919, that confirmation was obtained of the well-known fact that the efficiency of long range effective ammunition was not in the weight or muzzle velocity of the bullet, but in the shape of the base. Although this had been known for a long time, and the American Expeditionary Forces had particularly called attention to

Fig. 7. Elevation and Deflection Screen

the superiority of this type of bullet, yet nothing was so convincing as the range data obtained at this time.

At Miami determinations were also made of drift by the simultaneous firing of two service rifles with right and left hand twist types of rifling.

Firings on Daytona Beach, 1919.

During May, 1919, an auxiliary ballistic station was opened at Daytona, Florida, for the purpose of obtaining machine gun dispersion on sand and for other purposes, such as character of impact of bullets at long range on sand, etc.

This beach is one of the most remarkable in the world, being composed of a very fine, white, hard sand, which at low tide averages one hundred yards in width, and permits of marking machine gun dispersion with wire pins stuck in the bullet marks, and taking measurements by transit.

The work done on this beach, which is the location of the famous automobile racing course, was extremely accurate, but it was also exceedingly slow. Its great advantage was that the tide coming in and washing out the shot marks once every twelve hours gave a clean slate for each day's firing.

The speed of the water range, however, was absent, so that only a limited amount of firing could be done in a day, thus introducing the variable factor of weather conditions.

Toward the latter part of the Florida firings, during the Spring of 1919, most of the personnel of the station was discharged due to the Armistice, and the remainder were transferred back to Springfield Armory.

Development of the Mann Rest.

In the summer of 1919, as a result of the previous experience in firing, experiments were directed toward the development of a better mechanical means of testing the ballistics of small arms ammunition. This resulted in the adaptation of the so-called "Mann Rest" for this work, this device having been originally designed by that remarkable experimenter, the late Dr. Franklin W. Mann.

This rest, consisting of a V-shaped cast iron trough fitted to a Browning Machine Gun tripod, had been used successfully for long range tests at Borden Brook in the summer of 1919. The Mann Rest is the most accurate shooting device yet developed, and is a long stride forward in perfecting the technique of testing small arms ammunition.

The Florida Firings of 1920.

While the original Florida firings had resulted in securing an experimental bullet of great ranging ability with one of the flattest trajectories of any small caliber projectile so far designed, yet this bullet was still in the experimental stage and it was necessary to reorganize a personnel and return to Florida to finish the work. The Small Arms Ballistic Station was therefore reopened during the latter part of October, 1919, for the purpose of completing the firing necessary to reach a final decision on the new bullet. Moreover, the technique of firing had been so much improved that it was decided to repeat some of the previous experiments, even though the methods formerly used had been superior to any firing held in the past.

Fortified by the Mann Rest the station performed some remarkable experiments. The rest, as used in Miami in conjunction with a screen, is illustrated in Fig. No. 5, showing method of elevating barrel by quadrant to the nearest minute, and a transit for recording vertical and horizontal angles made by the bullet in its passage through a screen at 100 feet from the gun.

It was at this time that a remarkable series of very successful tests was accomplished with small arms projectiles in vertical firing. So precise were the methods that a .30-caliber bullet was actually caught in a bucket of water after it had traveled straight up and back for nearly a minute's total time of flight.

Final Closing of the Miami Range and Opening of Small Arms Ballistic Station at Ormond Beach, Florida.

Before the final experiments were completed the expiration of the lease at Miami forced the closing of the station the first of the year 1920. The work was resumed at Ormond Beach, Florida, on a site a few miles to the north of Daytona Beach, where the tests of the previous year were held.

An entire new system of range measurements was instituted so as to increase the speed of beach firing. A rectangular system of co-ordinates was devised to take the place of the former transit and stadia method of plotting shots on the sand. So proficient had the personnel became that it was possible to measure a burst of 100 rounds fired from the Browning Machine Gun at any range in less than five minutes, the accuracy of measurement being to the nearest yard in both length (range) and width (deflection). This was good work considering that the total area sometimes covered was several hundred yards in length by fifteen to twenty yards in width.

Fig. No. 6 shows such a burst from a Browning Ma-

chine Gun, although in this case, due to the shortness of the range and the consequent narrowness of the area of dispersion, the measurement was comparatively easy.

The labor connected with the measurement of all shots passing through a paper screen was very much reduced by the design of a screen so constructed as to allow the roll of paper always to be placed at any desired position by means of ropes operated from the gun platform. (See Fig. No. 7.) Likewise the paper could be unrolled from the firing position, which permitted a clean sheet to be used for each burst. This screen facilitates rapid work, as it allows the fire control officer to observe at all times the elevation and deflection he is obtaining on each burst, and the nature of the dispersion, *i. e.*, whether it was normal or not, as a bad set up or laying of the gun always showed on the screen.

The tests fired on the beach were especially valuable, in that by photographing the impact of the bullets on the sand a permanent record was obtained which could be observed and studied at leisure. Fig. No. 8 shows the impact in sand of the service bullet at 2600 meters (2,850 yards), and Fig. No. 9 shows the impact in sand of a boat-tailed .30-caliber bullet at 4400 meters (4,800 yards). The service bullet has lost most of its forward velocity and is descending at great enough angle to stick in the sand, while the other type of bullet has a trajectory so flat as to ricochet at the great range (for small arms) of 5,000 yards.

The beach permitted data to be obtained upon striking energy, penetration and angle of fall at all ranges. Time of flight was determined by means of microphones and other devices. All types of bullets were fired vertically upward, and the nature of the impact upon return studied for evidences of unstability, due to lack of spin.

The beach firing was not all confined to long ranges, as tests were fired on a short range 1,200 yards long, parallel to the beach, using the usual form of vertical paper targets. The phenomena of drift was investigated by using paper screens at as great ranges as possible and then continuing the investigation at still greater ranges on the beach.

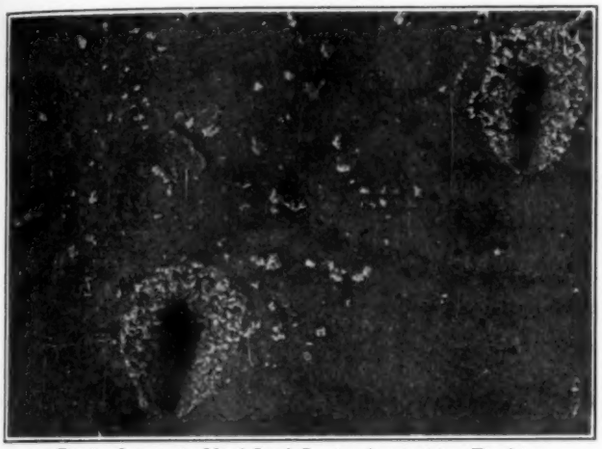


Fig. 8. Impact in Hard Sand, Service Ammunition, Fired in Browning Machine Gun. Range 2850 yards

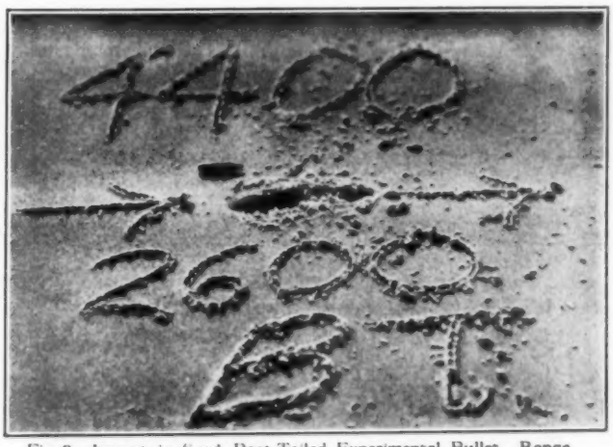


Fig. 9. Impact in Sand, Boat-Tailed Experimental Bullet. Range 4800 yards. Arrows indicate direction of flight as bullet richocheted. For purpose of comparison bullet is shown.

Conclusion.

The range work was discontinued in the latter part of May, 1920, after a vast amount of data had been gathered for future reference. The equipment of the station, together with some of the personnel, was transferred to the Department of Experiment at the Infantry School, Camp Benning, Georgia.

Thus closed a series of firings unique in the history of our Army, and which are believed to have been of inestimable value. The study of the data has just begun, and when completed will undoubtedly result in new ballistic and fire control tables, as well as other important changes.

San Francisco District of A. O. A. Organized

Members of the Army Ordnance Association residing in and near San Francisco, Cal., held a luncheon meeting at the Palace Hotel on December 20, 1890. With a view to creating and maintaining interest in industrial preparedness, it was unanimously decided to form a local unit of the A. O. A., to meet at luncheon once a month for discussion of ways and means of furthering this desirable end.

An executive committee and a committee to increase membership were appointed, and plans were made for the unit to present to the Metal Trades Association of San Francisco and the local section of the American Society of Mechanical Engineers, the advantages of having the executives and technical assistants of local metal industries and mechanical engineers become members of the Army Ordnance Association. It is also planned to hold a general meeting of eligible prospective members in the Assembly Room of the San Francisco Chamber of Commerce at an early date.

Colonel O'Hern, C. O. of Benicia Arsenal, offered to arrange for a meeting at a date to be fixed later for an inspection by members and prospective members of ordnance material at Benicia Arsenal.

On January 19, 1921, a second meeting was held at which the San Francisco District was formally organized. The new District will include all the industrial centers within 150 miles of San Francisco. Col. Bruce Cornwall was elected District Chairman, and he immediately appointed a permanent executive committee, consisting of Col. D. C. Seagrove, Col. Philip R. Faymonville, Mr. C. H. Snyder, Mr. Frank C. Sykes, and a District Secretary, Mr. Wm. H. Nanry, of 128 Sutter Street.

Mr. Metcalf of the Metal Trades Association of San Francisco, promised the hearty co-operation of that body in building up the new A. O. A. District.

The German Long Range Guns

By

K. F. ADAMSON

Member A. O. A.

OF the many instruments of destruction that were introduced by the Central Powers during the World War for use either against the combatant forces or the civilian population of the Allied Governments, none probably caused more comment or popular wonder than the long-range guns used for the bombardment of Paris from March 23 to August 9, 1918. Much has been written regarding the details and characteristics of these guns, but unfortunately it has all been based upon indirect evidence which to date has not been confirmed, so a true description is as impossible to-day as when the bombardment started. However, certain items have recently developed which deserve consideration and these lead the writer to believe that the data heretofore submitted, regarding, particularly, the length and type, must now be questioned.

In analyzing the ultimate success of this weapon, it is necessary that it be considered from a number of points of view. Generally speaking, a piece of artillery is judged by its destructive ability and when these guns are so analyzed it may be safely said that they were failures, for the amount of damage to property per round fired was no greater than would have been caused by an ordinary 6-inch high-explosive shell. The deaths and injuries average only about two and one-half per round, which is low when it is remembered that a thickly populated city was being bombarded; this number would have been much less if it had not been for three chance shots which caused about one-third of the total casualties.

As an artillery curiosity these guns exceeded anything in the way of range that has ever before been attained and in that respect were entirely successful. They also demonstrated a new fact in exterior ballistics, namely, that a greater range could be attained, for certain calibers of guns, when fired at an angle of 50° than at the previously thought angle of about 42°.

There was, however, a strategic reason for the use of these weapons and as we look back we realize that this piece of strategy was nearly successful and failed only because the French technical experts were able to determine the true character of the weapon on the first day of the bombardment. It is believed that the intention of the German High Command was to cause the civilian population in Paris to think that the bombardment of their city was being carried on by ordinary heavy field artillery which would immediately cause an exodus to the south and west of France, thereby throwing such a load upon the rail transportation systems that serious interference to the movement of troops and supplies would result, as well as causing a low morale through the Provinces and the Army. This exodus did start, but it came to a halt quite suddenly because it was learned that the shells were coming from guns situated more than 75 miles away. A fact that leads one to believe that the enemy desired to convey this information may be found in their Communique of March 24, which stated that Paris was then being bombarded by their *heavy artillery*. Those who understand the German mind and its love for the colossal can readily believe that he would not have lost this opportunity of impressing upon his own people and upon those of the allied nations the true facts, except for the purpose of deliberate misrepresentation of military knowledge.

In presenting the information that is now available, we will start with our direct evidence and build upon this such indirect evidence as we now have and thereby attempt to arrive at the probable correct conclusions regarding the actual characteristics of the guns and the number that were used during the entire bombardment.

Over 300 shells that have been located fell in Paris and its immediate vicinity, but unfortunately none of these failed to explode; therefore, we cannot give an exact sketch or description, but sufficient fragments have been found and examined to make it possible to build up a shell which we believe is rather exact except for minor details.

Fig. 1 shows the body of the shell with its probable dimensions. The nose of the shell consisted of a false ogive made of relatively thin and very soft metal which was mashed into an unrecognizable mass immediately upon striking. However, it is believed that it was about 710 millimeters long and either conical in shape or having an ogival radius of about 10 calibers. The body of the shell had a flat base with a small projection near the center into which was screwed a copper plate used for protecting the fuse. Some of the last shells to fall had a slightly tapered base which seemed to show a tendency towards a boat-tail design of an angle of about 30°.

The wall was about 42 millimeters thick at the bottom, tapering to about 25 millimeters at the top, with two rotating bands, one near the base and the other midway up the body. The forward one was probably rifled so that the seating of the projectile was actually made only by the rear band. The shell itself was also rifled, for a distance of approximately 70 millimeters in front of each of these bands. This was necessary because there was not sufficient strength in the copper band to make the shell rotate when passing through the gun at the tremendous velocity required. The top of the shell was closed by a cap screwed into the body and on which was screwed the false ogive, and midway between this and the base was screwed a diaphragm containing a large threaded opening in the center with six unthreaded holes around it. The introduction of this diaphragm was probably necessary to prevent the high explosive material from moving towards the rear, due to inertia, thereby causing either a detonation due to friction of the particles upon each other or such a high density of loading as to prevent detonation by the fuses. This diaphragm in all probability contained a fuse in addition to the one located in the base and operated independently.

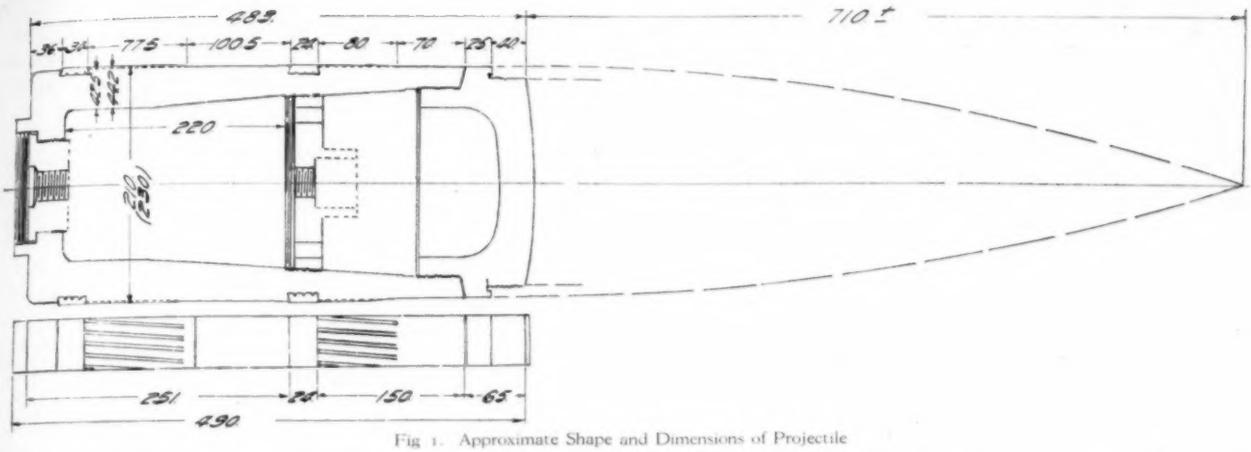


Fig. 1. Approximate Shape and Dimensions of Projectile

If this is true, it explains why no duds have been found, for, assuming a rate of fuse malfunction of 5 per cent, which is a fair average for the type used, the actual rate would be 5 per cent squared or one in 400 rounds.

The chemical composition of the body of the shell has been determined to be about as follows:

	Per cent
Carbon	.60—.80
Silicon	.25—.30
Sulphur	.03—.05
Phosphorus	.03—.05
Manganese	.30—.50
Chromium	1.3—1.5
Nickel	2.0—2.3

The elastic limit of the metal has been found to be about 114,000 pounds per square inch, the ultimate strength about 150,000 pounds per square inch and a Brinell hardness of from 300 to 350 units.

All of the first shells that fell on Paris prior to the 27th of May were 21 centimeters in diameter while those after this date had a diameter of 23 or 24 centimeters. However, there was no change in the number of lands, or any appreciable change in the weight.

It can be said that these located shells constitute the only positive evidence we have that Paris was actually being bombarded by artillery. However, the allied airmen located three gun emplacements in the vicinity of Laon which seemed to be of such a nature as would be required for these guns. The preliminary information for determining the general location was obtained by noting the line of fall through the floors and walls of buildings that were being struck. This location has been recently confirmed by articles appearing in a late issue of the *West Deutsche Rundschau* and in that of the *Munchener Neueste Nachrichten* of March 29, 1920.

Assuming therefore that this location was the actual position of the guns, and from the previous description of the shells, we may say that our direct evidence regarding the material is that a 21 centimeter shell weighing approximately 120 kilograms (which figure was arrived at from

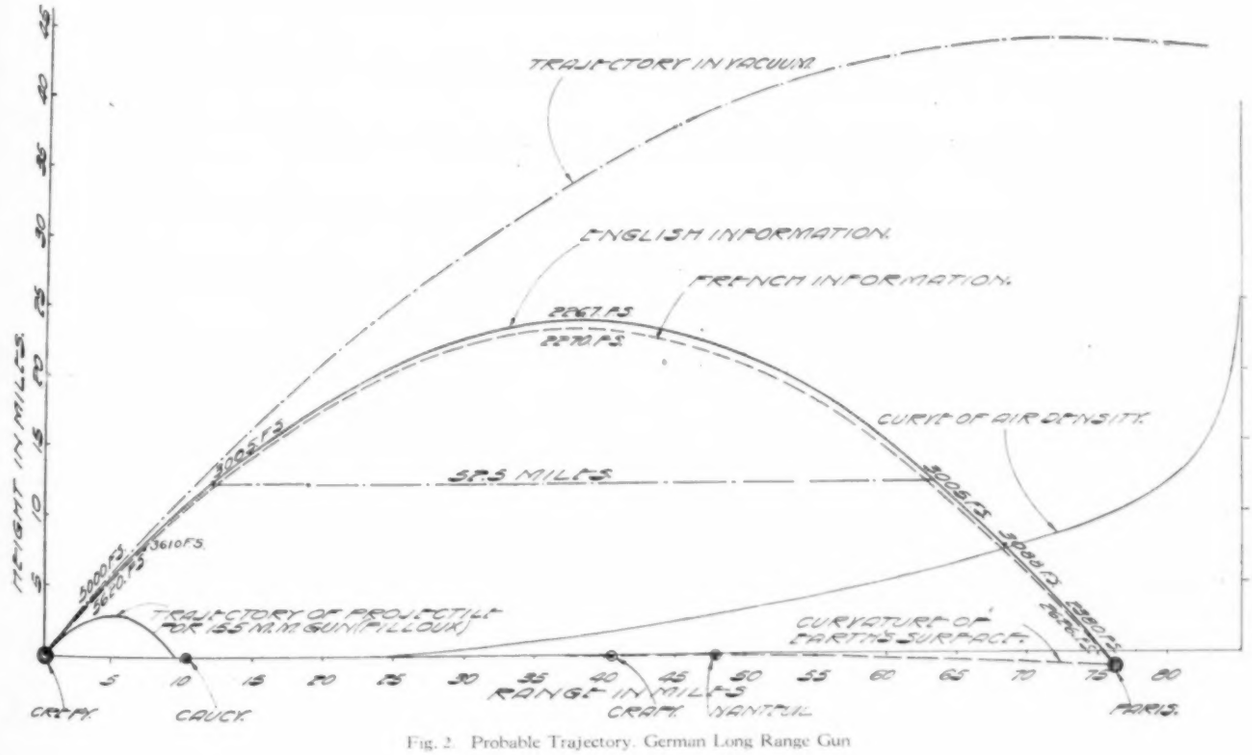


Fig. 2. Probable Trajectory. German Long Range Gun

fragments, and later confirmed by Professor Langner of the Skoda Works) was being fired a distance of 122 kilometers; that the muzzle velocity was very high as shown by the fact that rifling was of a 4° slope. A shell of this nature would have a ballistic co-efficient of about 10, based upon the American system of notation if its form factor was as low as .39. While this latter figure is exceptionally good, it is not better than might be expected when the results obtained by the German field artillery during 1918 are considered.

Figure 2 shows the probable trajectory of a shell for a range of 76 miles. The two curves are based upon calculations made by Major J. Maitland-Addison of the British army and from a French source of information. The curve of air density shows the reason for the tremendous ranges obtained while the projectile is in the upper stratæ of air, as it will be noted that the density at 12 miles is

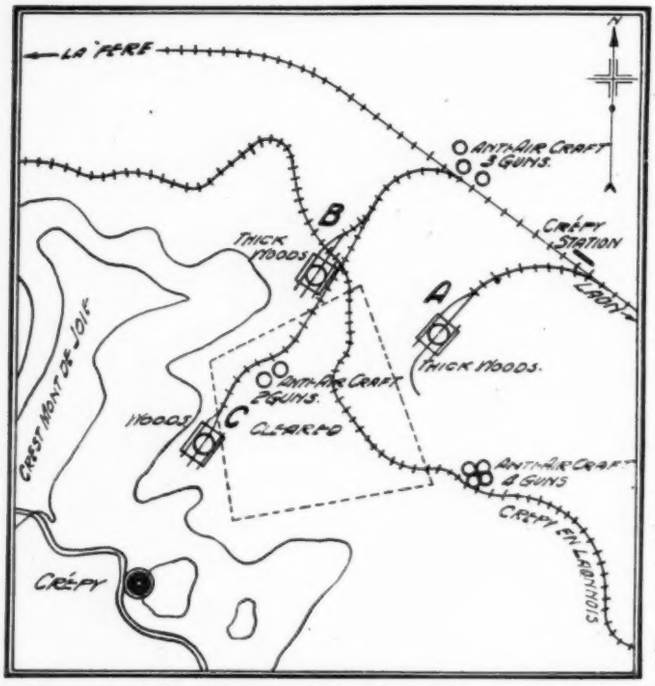


Fig. 3. Detail Showing Location of Heavy Gun Emplacements, probably German Long Range Guns

only about 8 per cent of the density at the earth's surface. In order that the reader may get a better idea of the flight of these projectiles, in the lower left hand corner is shown the trajectory of a 155 mm. G. P. F. gun firing at its maximum elevation and with its maximum muzzle velocity used during the World War.

The calculations applying to Fig. 2 were made before the armistice was signed and too much confidence should not be placed in them, although they are accurate enough to give us a starting point for future thought.

In the summer of 1919 a commission of American officers visited the Skoda Works and while there saw some 38 centimeter 45 caliber German naval guns that were being relined, and lengthened to an overall length of 36 meters, which correspond to a length in calibers of about 170. They were led to believe that these guns were of the same design as those that were used in the bombardment of Paris. This information is believed by the writer to have been incorrect, for the following reasons:

Why should these guns, in the process of manufacture, be left in these works for any one to visit and examine and yet the actual guns used in the bombardment be so completely hidden or destroyed that no one of the Allied Armies has ever seen them, even though the terms of the armistice required the turning over of one of them?

Moreover, it has been the boast of officers in the German Army that no one of the Allied Forces would ever see these guns.

The actual length of the gun which fired on Paris was probably not more than 21 meters, which would give it a length in calibers of about 100. This value has been obtained from a number of sources of questionable reliability, yet they are of such a nature that they can not be wholly disregarded. The same length is also substantiated by the designs that have been laid down by the British, French and American ordnance engineers who, when attempting to design a gun to equal the German gun, have never been forced to go to a value much greater than 100 calibers.

We are forced to assume that the German technical staff knew as much about gun construction and ballistics as those of the Allies and if this be so, why was it necessary that a gun of 170 calibers in length be constructed when the Allied services have been able to obtain the same results from 100 calibers?

It is believed that the Skoda guns would have fired a distance of 76 miles or more and that they were being constructed, after the necessary ballistic information had been obtained from the firing of the original weapons, in order to overcome certain structural faults. The main problem here was probably the development of a powder of such characteristics as to burn slow enough to maintain the required average pressure without developing an excessive maximum pressure.

Questionable information has been received from a former officer in the Austrian army who states that a multiple powder chamber was used in the original guns built, and while this information cannot be depended upon, we must give it consideration as it has been confirmed by two other sources. Some such feature as this may be the reason why so much care was used in the suppression of information regarding the actual guns employed in bombardment.

The number of long-range guns built is as much a mystery as their construction, but Dr. Langner, of the Skoda Works, states that the information he received when at the Krupp Works was that nine of these had been built of the 21 centimeters caliber. A high official of the Prussian Ordnance Board stated to an American officer that six guns blew up in proof-firing and that the Germans were so afraid that the Allies would learn the secret of its construction that all fragments were collected and immediately melted.

In the article referred to from the *Munchener-Neueste Nachrichten*, it is stated that three guns were in position for this bombardment. Other information has been obtained from sources that are not so reliable but which lead us to believe that the number as stated by Dr. Langner is probably correct and that the number of failures as stated by the German high official is also reasonable. Assuming therefore that three guns were originally used of the 21 centimeter caliber, we will analyze the firing figures, in order to determine the probable accuracy of this information.

Assuming that the accuracy of the gun was such that individual spots in Paris could not be fired upon with certainty, and therefore calling those that struck within the Paris walls hits on the target and those without misses, we arrive at some very interesting results.

It has been estimated that the life of these guns was about 50 rounds. This figure is checked reasonably close by the British Admiralty formula which has been found to be satisfactory for guns above 6 inches in diameter. By analyzing the daily log of the fall of shells in the Paris bombardment, we find that groups of about 50 rounds so divide the firing that a marked decrease in accuracy develops during the last few days of each period. To cite a specific example, on the 29th of March out of 4 shells fired only one struck Paris, while on the 23rd of March, the first day of the bombardment (a total of 21 shells fired) 18 fell in Paris. In the next series, we have 18 shells striking in Paris out of a total of 21 on the 1st day, and on the last two days there were only two hits out of a total of seven. By continuing down the remaining four groups, it will be seen that approximately the same conditions hold true. Attention is here called to the previously stated fact that all shells after the 27th day of May were of the 23 or 24 centimeter diameter, while all the shells before were 21 centimeters in diameter. From the above, the following conclusions are drawn: That the enemy had three gun emplacements, that he fired only one gun at a time and completely wore it out before using the next, that when his first gun was worn out, it was returned to the Krupp Works to be re-bored and re-rifled and that it was put in position again previous to the 27th day of May. The second gun was worn out about the 7th of April and was reconditioned and put in position about the 4th of June and the third gun was worn out about May 1st and remounted about August 5th. By so handling the material two months or more was available for the re-boring and re-rifling, a sufficient time for the proper execution of the work.

Another interesting fact regarding the handling of these guns is that the Allies have not been able to receive information from anyone who ever served with them at the front, although much fragmentary knowledge has been obtained from people who claim to have worked on them in the Krupp Plant and from others who claim to have authentic information as to the actual design. This leads one to believe that a small group of men were used in serving the pieces, which would not have been possible if all three guns had been manned at the same time.

From information and results previously referred to, the following table is offered as to the probable characteristics of the long range German guns:

Length ---------- 21 meters or 100 calibers.
Muzzle velocity ---------- 16 meters per second.
Maximum powder pressure 4000 kilograms per sq. cm.
Angle of elevation ---------- 50° +.
Ballistic coefficient ---------- 10.
Weight of projectile ---------- 120 kilograms.
Caliber ---------- 21 centimeters.
Caliber after re-boring ---------- 23 centimeters.
Number of grooves and lands 64.
Probable life of gun ---------- 50 rounds.
No. of guns used in bombardment ---------- 3 (each re-bored and again worn out).
Time of flight of projectile 3 minutes.

As stated at the beginning of this article, the information that has been learned regarding these guns is of a most uncertain and unreliable nature, and time only can tell whether the true history of these weapons will ever be generally known. They have, however, opened up a field of artillery work of which little is known, and while the actual usefulness of weapons of this nature is small at the present time, the United States Government should be sufficiently interested to carry on experimental work, in order to determine whether they can be reproduced with the facilities and knowledge now at hand, and if not, the greatest effort should be made to study and develop those principles governing gun construction which would make it possible to not only reproduce but to exceed the results obtained by the German weapons.

Characteristics of Long Range Gun as Shown in Fig. 2.

	British.	*French.*
1. Range in miles	76	76
2. Maximum height in miles	23.9	23.7
3. Time of flight in seconds	177	177
4. Muzzle velocity in feet per second	5000	5620
5. Angle of elevation	50°	48°-39′
6. Velocity of vertex—feet per second	2267	2270
7. Velocity point of fall—ft. per second	2626	2380
8. Ballistic co-efficient	10	8.78
9. Angle of fall	54°-40′	54°-51′
10. Weight of projectile in pounds	330	265
11. Caliber in inches	8.3	8.66
12. Weight of powder in pounds	400	441
13. Length in caliber	130	168
14. Maximum pressure, lbs. per sq. in.	47000	57000
15. Volume of powder chamber in cu. in.	22000	21400
16. Volume of bore in cu. in.	70700	88500

17. The breech construction to be either of a number of powder chambers in the gun itself or a specially designed cartridge case to give successive or prolonged explosions of increment powder charegs.

Restrictions on Travel of Reserve Officers Removed

The restrictions upon the travel or temporary residence abroad of Reserve Officers have been removed. Upon request addressed to the Adjutant General of the Army, such officers will be granted permission to travel or reside abroad without regard to the probable duration of such travel or residence.

EDITORIAL ANNOUNCEMENT.

Due to publishing conditions over which we have had no control, the issue of the January-February number of "Army Ordnance" has been unavoidably delayed. It also happened that an unusually large number of articles was received, of merit, both as to subject-matter and timeliness, so great as to make their publication in the current issue almost compulsory. In order to make the best of this condition of affairs and insure resumption of our regular publishing schedule, it has been deemed best to combine the next three numbers—January-February, March-April, and May-June—into two numbers, which will be called the January-February-March and April-May-June numbers. By July 1st it is anticipated that regular bi-monthly issue can be resumed.

ARMY ORDNANCE

VOL. I JANUARY-MARCH, 1921 NO. 4

". . . . But Keep Your Powder Dry!"

IN the one hundred and fifty years since the thirteen states formed the nucleus of a great new nation, what has been the deciding factor in each contention over a question of right and wrong in which America has been involved?

In the very first instance, when taxation without representation became tyranny, what means corrected the injustice against us? Arms. When foreign frigates searched our merchant ships and removed American citizens without right, what stopped this impressment of our seamen? Arms. When these United States were threatened with disruption over the fundamental question of the right or wrong of human slavery, what effected its abolition? Arms. When atrocities were committed in Cuba, compelling us in the name of humanity to intervene, by what did we halt this barbarism at our very shores? Arms. When our women and children were being gratuitously murdered on the high seas, what terminated this abridgement of the right of free peoples to pass and repass, unhindered, upon the world's waterways? Arms. Arms and armament. Not moral suasion, not logic, not reason, not an appeal to justice or a plea for mercy. In no single instance was an equitable decision arrived at without resort to arms. And in no single instance did we sally forth and provoke a quarrel because we felt an urge to establish ourselves as a great military power. We resorted to force for the fundamental reason that unless a man is willing to defend a principle he believes to be vital to the welfare of humanity either he or his principle is a bit weak in the knees, and if he feels that he must fight to defend it, he will fight with his bare hands, lacking other means of defense.

Wars always have arisen and always will arise from a difference of opinion as to the right and wrong of a given contention. History affords us numberless examples of men hating each other with a deadly hatred for love of the same God; and going cheerfully to the stake to sustain their conviction. There was a difference of opinion as to the justice of taxation without representation, as to the right of one human being to own another human being body and soul, as to the right of one human being to torture and oppress another human being, as to the right of one nation to encourage the wanton murder of the women and children of another—and these questions were settled to the lasting benefit of civilization only by a final resort to force. Abolish all the armament in the world, and men will still settle their disputes as they have since the memory of man runneth not to the contrary—with tooth and nail, with clubs, with bows and arrows, blunderbusses or machine guns—in short, with the means that is readiest to their purpose. Armament—the means of defense—can be put to bad uses, but so can a man's fists, and the blame should not attach to the armament but to the mind which conceives its employment on the side of evil instead of right. Cutting off a man's hands seems rather a drastic measure to take to prevent his possible belligerency.

The genius of eternal peace lies in the hearts of men. Nations are but collections of individuals and as such are capable of and susceptible to all the ambitions good or bad, the commercial rivalries, the patriotic fervors and the petty jealousies of the human atoms of which they are composed. History teaches the futility of seeking to unify the perceptions of great social units, such as nations, until a firm foundation leading to this end has been established among the lesser social units, such as states, municipalities, communities, and even families.

Let us experiment on a laboratory basis before putting a new and untried system into quantity production. Applying the disarmament theory to the community involves a willingness to forego the protection of bolt and bar, the disbandment of police forces, the discontinuance of penal institutions, etc. Are we ready for this practical test? It is only by thus reducing theory to actual practice and sensing the outcome of its application that we can realize the utter futility of assuming either that men will agree or can be brought to agree, as to what is right and what is wrong, or that, even if in agreement, they will, in the absence of compulsion, abide by what is right. There is a law against the carrying of concealed weapons, but every now and again we read of a shooting on a dark night.

A nation which is prepared to defend itself against aggression is a nation prepared for peace. The greatest bully in the world hesitates to antagonize a man who is equipped and skilled in the art of self-defense, however pacifically inclined an individual he is. A nation prepared for self-defense has to take less punishment, first and last, than a nation not prepared for self-defense, even as a man who is able to hold his own is not apt to be drawn into a careless quarrel. And it is well to remember that the punishment a nation suffers lies in the wanton waste of human life, in its youth disabled, in a great burden of taxation fastened upon its people compared to which the annual appropriations for sufficient preparedness are a light load indeed.

It is all very well to say that universal unpreparedness is the universal panacea, but a satisfactory modus operandi for this Utopian state of affairs has yet to be worked out. What practicable and equitable adjustment could be made between a nation that possesses highly developed plants and organizations trained in manufacturing munitions and armament and another nation totally unequipped for such manufacture? If every gun, fighting ship, piece of artillery, shell, every pound of powder in the world were simultaneously destroyed, some nations could develop fighting power in a few weeks, others perhaps never.

We are not a bloodthirsty race, and it is the least likely event in the world that at this stage in our national career we will embark upon an offensive war, seeking whom we may devour. But why we should assume, while the millions of men slain in the cruellest war history has ever known lie scarcely cold in their graves that humanity has been metamorphosed into a race of highly intellectual, judicial-minded, Socratic individuals overflowing with the milk of human kindness and brotherly love, is beyond comprehension. We heard many laments that Germany had set the clock of civilization back by hundreds of years. It is well not to try the other extreme by endeavoring to speed up the hands of the clock in one mighty whirl, allowing no hour in its natural evolution to strike. The works will surely jam.

As Americans we have every reason to trust America. We can continue to live safely in this trust only so long as we are able to be captains of our own destinies.

BACK NUMBERS WANTED.

Requests for back numbers of "Army Ordnance," particularly the July-August, 1920, number, are being constantly received at the office of the Secretary. Members who can spare their copies and who will mail them to the Secretary of the Association at Room 410, Munsey Building, Washington, D. C., will render a service to the Association by extending the field of its usefulness.

The Council of National Defense

By

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The Act of Congress creating the Council of National Defense in 1916, was an item of constructive legislation toward national preparedness that stands preeminent in the progress toward national security. However, the Council was created such a short time before the entry of this country into the World War that it was impossible to work out a well-planned organization. It is safe to say that if the Council had been given the power of direction and control it would have evolved sub-divisions of its organization to perform the work of the War Industries Board, the Fuel Administration, the War Trade Board and the other organizations that were created to meet the necessities of war.

No amount of preparation will enable us to dispense with some organization exercising in war the functions of the War Industries Board, because, despite the most careful plans, contingencies will arise requiring the intervention of such an authority.

In connection with any pre-war plans for the mobilization of industry, a central body acting in the capacity of a national General Staff is indispensable. Without such an organization to initiate, co-ordinate and direct the study made in the several executive departments, no definite results can be attained.

While conditions existing during the World War made necessary the formation of the various units referred to above, or at least justified their organization, it is asserted that it will be fundamentally faulty to include in the preparation of plans for another industrial mobilization a body to be brought into existence for the exercise of the functions of the War Industries Board after the emergency has arisen, or even when it is seen to be imminent. The plans should include the utilization of an existing agency, if there be any such, or, if not, necessary steps must be taken to secure legislation creating a body capable of doing its part in peace-time preparation and in time of war of executing such of the functions of the War Industries Board and allied organizations as may be then necessary.

Fortunately, there is no necessity for the creation of a new agency. The law creating the Council of National Defense assigns to that body functions that make it peculiarly suitable as the co-ordinating agency in formulating plans for the industrial mobilization of the country for war or other great emergency, and in war of exercising such executive functions as may be necessary. The organization of this body, therefore, should have two objects—first, to perform its part in the work of preparation, and second, to allow for an orderly and immediate expansion to meet the war demands that may be made upon it. With such an organization the only action necessary to enable it to execute its war-time functions will be an executive order. Such order can only be issued pursuant to legislative authority similar to that contained in the so-called Overman Act, but it is assumed that such legislation will be enacted.

A brief consideration of the organic law and its obvious method of application will show the essential part that the Council must take in any plans for industrial mobilization. The Act, approved August 29, 1916 (Bulletin 33, War Department, 1916), provides, among other things, as follows:

> That it shall be the duty of the Council of National Defense to supervise and direct investigations and make recommendations to the President and the heads of executive departments as to the location of railroads with reference to the frontier of the United States so as to render possible expeditious concentration of troops and supplies to points of defense; the co-ordination of military, industrial, and commercial purposes in the location of extensive highways and branch lines of railroad; the utilization of waterways. the mobilization of military and naval resources for defense; the increase of domestic production of articles and materials essential to the support of armies and of the people during the interruption of foreign commerce; the development of seagoing transportation; data as to amounts, location, method and means of production, and availability of military supplies; the giving of information to producers and manufacturers as to the class of supplies needed by the military and other services of the Government, the requirements relating thereto, and the creation of relations which will render possible in time of need the immediate concentration and utilization of the resources of the Nation.

It should be noted that the Council is composed of the heads of six of the Executive Departments. These six departments may be divided into two classes. First, those which represent the great users in war time—the War and Navy Departments—and second, those that represent the productive capacity of the country—Agriculture, Commerce, Interior and Labor. The Council is the great coordinating agency in the preparation of plans for industrial mobilization to meet a national emergency. By virtue of its membership, it can assemble statements of requirements, data as to sources of supply, and after a comparison of the former with the latter, reach conclusions as to allocations of facilities to satisfy needs. Such allocations can be made by the Council acting for the President, and will enable the various requiring units to proceed in an orderly manner to make their detailed plans for securing the necessary supplies. In cases where facilities are inadequate to meet requirements, the Council is the proper agency to study the problem, determine the measures necessary to meet the deficiency and to initiate the proper action.

The Council consists of the Council proper and the Advisory Commission. After the dissolution of the War Industries Board at the end of the war, the Council formed itself into a subordinate organization known as the Interdepartmental Defense Board. This is its real working unit. It consists of a representative of each of the Executive Departments whose heads form the Council proper and is under the chairmanship of the Director of the Council. Under a recently proposed reorganization of the Interdepartmental Defense Board it will have an Executive Committee consisting of the Director, the War Department representative, and the representative of the Navy. The advantages of such a Committee lie in its small personnel and in the fact that it has on it the representatives of the two Executive Departments which are the principal requirers in war, and which are, therefore, most concerned with adequate war preparation.

The role assigned by law to the Council of National Defense does not contemplate or require a large organization. For its peacetime activities, it can readily accomplish its task with a very limited personnel, relying on existing agencies to furnish the data needed for the development of plans of preparation. The degree of expansion to meet war conditions depends directly upon the completeness with which we solve our supply problems before the emergency arises.

On January 3, 1921, the House of Representatives, in the consideration of the Sundry Civil Bill, eliminated the item covering an appropriation of $75,000 for the next fiscal year for the support of the Council of National Defense. No fair-minded citizen can take exception to the desire of Congress to limit appropriations to essential governmental activities. Now, more than ever before, there is need for rigid economy. There is no economy, however, in eliminating an item for the support of an activity so important to the public welfare as is the Council of National Defense.

In the development of pilot matériels under the Westervelt Board program, great credit is due Frankford, Rock Island, Watertown and Watervliet Arsenals for assistance in improving details of designs, in suggesting modifications to make the matériels more easily manufactured and in developing new and semi-finished materials for use in them. Especially valuable results have been obtained from the organization at Rock Island Arsenal in working out the details of mobile carriages and in the manufacture of wooden models.

Models. The Ordnance Department has established in the Munitions Building an interesting collection of wooden models of all of the new types of artillery matériel which are under manufacture in accordance with the new development program. As soon as the pencil drawings of the various types were completed, full-size wooden models were manufactured. These models have been of great assistance in checking the correctness of design and in correcting defects. Their cost was relatively small as compared to the cost of actual matériel, and it is estimated their manufacture will effect an ultimate saving in the total cost of development of many times the cost of the models. The collection is also of value as it enables the artillery and ordnance officers to obtain a clearer conception of the progress and character of development work. Actual pilot matériel of each of the types is now under production, and firing tests have already begun on two types of 75-mm. matériel.

75-mm. Field Matériel. The Rock Island Arsenal completed the manufacture a few days ago of the first unit of 75-mm. matériel, and preliminary firing was conducted at the Arsenal on December 22, in order to make adjustments of the gun and carriage. The gun was manufactured at the Watervliet Arsenal. This gun has the ballistics called for under the new program of development. No firings for range will be made at the Arsenal, but it is expected to obtain 15,000 yards with a 15-pound projectile. This is about 3,000 yards in excess of any range obtained with 75-mm. matériel used during the World War. There is, of course, no great difficulty in obtaining any range desired from a gun of this caliber were it not that the restrictions as to weight of matériel are very rigid; and increase in range also calls for a larger powder charge, which greatly increases the difficulty in supplying and handling ammunition.

The carriage being tested is of the Split Trail type, permitting elevation from minus 7½ degrees to plus 80 degrees, and a total traverse of 30 degrees. The carriage is equipped with the independent line of sight system and variable hydro-pneumatic recoil. This carriage will later be tested in comparison with a Single or Box Trail carriage, which is now under manufacture. Artillery officers both here and abroad differ in their opinions as to the relative merits of the Split Trail and the Box Trail types of light field carriages. Both types have distinct advantages, and it is very difficult to determine which type is on the whole the more acceptable. The Split Trail Carriage is somewhat more complicated, and is heavier than the Box Trail type. On the other hand, it permits wide changes in direction of fire without shifting the carriage itself, and this is considered, by some, of very great importance, as it is difficult to shift the carriage in very soft ground or in frozen ground.

75-mm. Pack Matériel. The Rock Island Arsenal has completed the manufacture of the first 75-mm. Pack or Mountain Howitzer Carriage, and has assembled the Howitzer, which was made by the Watervliet Arsenal. A few proof rounds have already been fired. This matériel being packed on mules for transport, must be so designed that it can be quickly disassembled for packing in individual loads not exceeding 225 pounds each. This requirement makes the design problem somewhat more difficult. Mountain or Pack Howitzer matériel was not used by our army in France, although if warfare had become more open and had such matériel been available, it is very probable it would have been requisitioned. The Mountain Howitzer matériel now in use is known as the 2.95-inch Vicker's Mountain Gun, and while it has given very satisfactory performance in the Philippines in breaking up Moro strongholds, it is nevertheless in various ways unsatisfactory. The Howitzer has no traverse on the carriage, and is laid in direction by shifting the trail. The recoil being very short, the carriage is also very unstable in firing, and it follows that it must be relaid both in elevation and direction after each round. The new matériel has been designed to overcome these and other objections. It will fire the 15-pound projectile used in the light field gun, and will have a range of about 6,500 yards, which is considered ample for this type of artillery. An experienced pack-master is being ordered to the Arsenal to conduct pack tests. Preliminary firings for adjustment were held early in January.

Compression of Water. Quite recently, in the course of preparatory work on auto-frettage at Watertown Arsenal, special forms of packing were tested for use under high pressures, the great compressibility of water proved for a time to be a rather annoying factor. While the occurrence might seem of trivial importance to the initiated ones, it may prove of interest and of service to the uninitiated who, most likely, are in the majority; it is with this object in view that the matter is mentioned here.

In general practice liquids are considered as incompressible. This follows naturally from the statements in works on Hydraulics. One typical authority says that reduction in volume of liquids under compression is obtained only through very great efforts, and it is only by repeating the tests with special precaution that modern physicists have determined the very small values of the coefficients of compressibility.

In the case at hand a heavy tube was fitted at one end with a cup packing resting upon a plug screwed into the tube; at the other end was a hollow plug attached to the tube, with a U packing on the inner side. One 4-inch moveable plunger fitted the plug and the packing. The tube was filled with water, precautions being taken for the exclusion of air, and with the plunger in position, the whole apparatus was fitted in place on the large Emery testing machine. With the application of pressure upon the plunger it was found that the latter moved steadily into the cylinder at a rate proportional to the pressure. Thus at 1,000 atmospheres the penetration was 15 inches. It was thought at first that this enormous displacement was due primarily to the presence of free air in the cylinder. The latter was then refilled with distilled water and extra care was had for the exclusion of air. There was no appreciable difference in the displacement of the plunger under pressure.

The initial volume of water was about 3,975 cubic inches; the distension of the cylinder proper under a pressure of 1,000 atmospheres was about 7 cubic inches; the displacement of the plunger was 188 cubic inches. Consequently, the coefficient of compressibility of the liquid was apparently 0.0000475. The truer coefficient determined with utmost care by Grassi, is about 0.00005 for the temperature obtaining at the Arsenal Laboratory; later on Amagat found other values which varied with the pressure. The agreement is remarkably close when it is considered that no special preparations had been made to measure the volumes involved and that the observation of the phenomenon was not planned, and, in fact, was but a mere incident in the conduct of the test intended.

No less remarkable was the perfect elasticity of the liquid which caused the plunger to return exactly to its initial position upon the removal of pressure, or to move proportionally to the intensity of the pressure. The notion that liquids are practically incompressible is rather widely accepted by practicians and it is little realized that, as Professor Merriman states in his treatise on Hydraulics, water for instance is about 100 times more compressible than steel, its modulus of elasticity being in the neighborhood of 300,000. Incidentally, warning may be given that because of this fact, and in similar instance of application of high internal pressures in long cylinders, should the systems give way through breakage or buckling, water would not act merely as the inert body it is popularly accepted to be, but rather as a mighty spring, quite likely to cause grave damage both to material and to the operators.

The New 16-inch Coast Defense Weapon. The largest and most powerful piece of ordnance ever built in the United States has just been comp'eted. The rifle was manufactured at the Watervliet Arsenal, New York, and the carriage at Watertown Arsenal, Massachusetts.

The new 16-inch rifle is about 69 feet overall, and weighs 340,000 pounds. It gives a muzzle velocity of 2,700 f. s. with a 2400-pound armor piercing projectile. The propelling charge consists of 850 pounds of smokeless powder.

The disappearing carriage, upon which the gun is mounted, weighs about 850 tons. It permits the gun to be fired through 360 degrees of

traverse, and at a maximum elevation of 30 degrees. The range of the piece at this elevation is over 40,000 yards.

In the fortification the gun and carriage are placed directly behind a large parapet of concrete and sand, having sufficient thickness to protect the gun and carriage from shell fire.

In order to give some idea of the size of this unit, it may be stated that the distance from the axis of the piece to the bottom of the counter-weight pit is 49 feet. When fired the gun sinks to a position about 12 feet below the firing position. The gun is loaded in this recoiled position. One important feature of this type of carriage is that the gun can be laid in elevation in the recoiled position, thus enabling it to be fired the instant it rises above the parapet. The energy of recoil is absorbed principally in raising a counter-weight weighing 313 tons, and in throttling the oil in the recoil cylinders attached to the carriage, through orifices of varying dimensions. Although the gun and rotating parts of the carriage weigh 790 tons, they can be easily turned in direction by the force of one man applied at the traversing handwheel. The carriage is provided with a periscopic sight similar to that used in submarines, so that the gun can be trained in direction upon the target by the gunner standing below the parapet.

Although the carriage is hand-maneuvered throughout, it is also provided with electrical equipment for elevating, traversing, lighting and firing the piece. The weapon will have an estimated rate of fire of one shot per minute. The carriage is provided with light armor to protect the personnel from aircraft machine gun fire and from earth and debris, which might fall upon the carriage if enemy shell should strike the parapet.

Defective Gun Forgings. The following table gives the chemical and physical characteristics of four fragments of the tubes of two 240-mm. howitzers which have blown up during proof firing:

240-mm. Howitzer No.		48		29	
Fragment No.		3	9	4	5
Chemical analysis—					
C	------	.39	.40	.41	.40
Mn	------	.59	.58	.66	.67
Si	------	.135	.135	.140	.115
P	------	.039	.040	.037	.037
S	------	.029	.031	.032	.032
Ni	------	3.09	3.22	2.72	2.72
Cr	------	.19	.12	.00	.13
Phy. prop. required by spec.—					
E. L	65000	63500	58000	66000	64500
T. S	95000	100000	101500	101500	99000
Elon—per cent	18	24.5	20.0	24.0	20.2
Red—per cent	30	44.8	51.8	51.0	36.8
Charpy tensile	------	155.	169.	162.	168.
Charpy notched tensile	------	14.55	18.07	16.76	17.42
Charpy notched impact	------	15.88	12.84	18.84	19.16
Brinell hardness	------	193.	196.	185.	197.
British bend test	------	------	28300	28800	------

Both of these howitzers were blown up at pressures of only about one-half for which they were designed, and an analysis of the preceding figures shows that those physical properties which are generally considered in specifications for steel products agree rather satisfactorily with the specifications as laid down.

The design of a cannon is at the present time based upon the assumption that it is stressed by a static pressure. If this is true, no reason can be offered as to the cause of these explosions. An alternate theory as to how cannon are stressed is based upon the supposition that a dynamic load is applied and not a static load. The Charpy tests, particularly the notched impact, is a measure of the ability of a substance to withstand shock, and by an inspection of item marked "Charpy notched impact," we note that there is a 50 per cent variation of the several samples. These values themselves do not represent the actual variations of the tests' results, for each of the above is an average of two or more steel specimens, and the actual valuation between the low and the high Charpy was about 125 per cent.

Gun steel has been recently analyzed at the Watertown Arsenal which did not exceed appreciably the above in elastic limit, ultimate strength, etc., yet did show a uniform Charpy of about 45-foot pounds which may explain the reason for the failure of these two howitzers.

An Experimental System of Recuperation. In the recuperator or counter recoil system of certain gun carriages it is customary to separate the oil chamber from the air chamber by a floating piston which forms a complete seal between the two. The gun upon recoiling draws the recoil piston to the rear, this movement forcing oil in rear of that piston through a valve or port at the rear end of the cylinder. The oil thus entering the recuperator cylinder pushes the floating piston forward, compressing the air which thus provides the energy required to return the gun to its initial position.

In order to prevent any escape of air by the floating piston, it is necessary that this piston shall move in a highly finished cylinder and the packing assembled so tightly that the radial pressure prevents escape of air. Although the construction is such that the pressures on the air and oil sides of this piston are nearly balanced, experience has shown that it is extremely difficult to retain air for long periods under the high static pressure necessary, and this has resulted in the development of a very complex piston and very exact and highly finished moving parts.

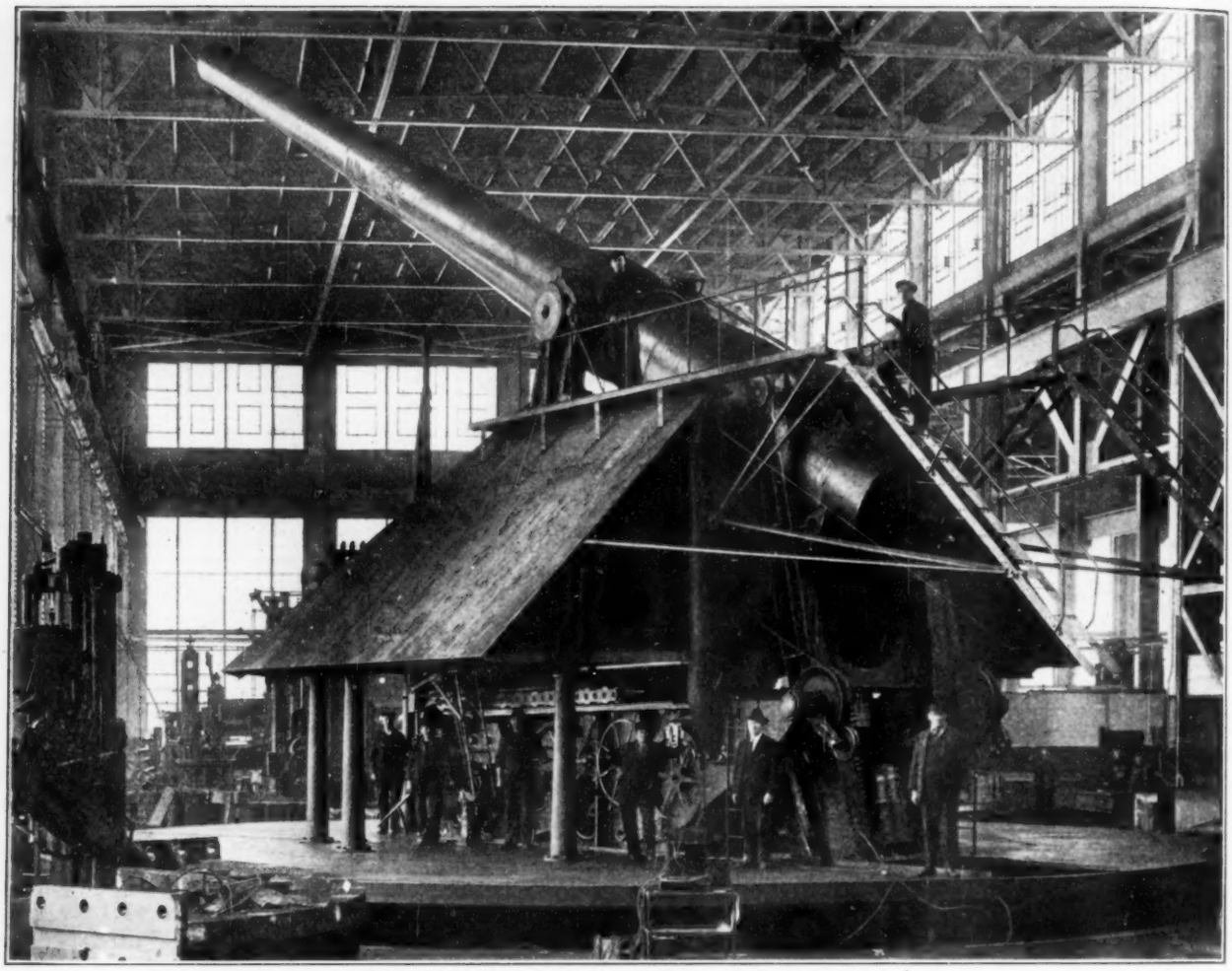
In the manufacture of mechanisms in this country considerable difficulty was experienced in obtaining the necessary accuracy and finish in the bored cylinders; also the assembly and adjustment of parts was found to require exact knowledge, skill, and much time. The problems of manufacture were successfully met, and the Department now feels there is no doubt that manufacture of these mechanisms can be placed on a production basis. It has been felt, however, that effort should be made to see if it is possible to reduce the number of parts in these mechanisms, and also the skill and labor which is necessary in their assembly.

Since the mechanisms which we are now using were invented abroad, have been successfully produced in large quantities, and have given general satisfaction and excellent performance in service, it would, of course, be presumptuous for us to suggest changes after our very brief acquaintance with them, and without first-hand knowledge of the numerous engineering difficulties which were undoubtedly met with in the course of development, and which were successfully overcome, at least as far as performance in service is concerned. And the latter is after all the real test.

No such effort to introduce hasty changes or possible improvements can of course be countenanced, except in an experimental degree. After experiments have demonstrated that new devices insure improvement in design, manufacture, or in performance, it is then possible to consider their adoption for service use under other limitations, such as that of interchangeability or of uniformity, which will then arise.

Such efforts, therefore, to introduce improvement are very desirable, and must be encouraged if progress is to be made. It is the purpose of this paper to present a proposed new system of recuperation, which has been tried experimentally to a moderate degree, and which appears to possess sufficient promise to permit discussion of it as something which is within the realms of possibility. The design of this improvement was made by Maj. B. B. Holmes, who served with the Coast Artillery during the war, and who was called to duty in the Ordnance Office for some months prior to his return to civil life so that he could devote his full time to its development with the assistance of ordnance engineers of the Department.

The basic feature of the proposed system is to enclose the air in an elastic metallic bellows, which is constructed by rolling deep circular convolutions in a thin walled seamless tube. The nature of this bellows will be understood upon examination of the drawing herewith. Bellows of this character are manufactured by the Fulton Company of Knoxville, Tennessee, and those used in the preliminary test were supplied by that Company.

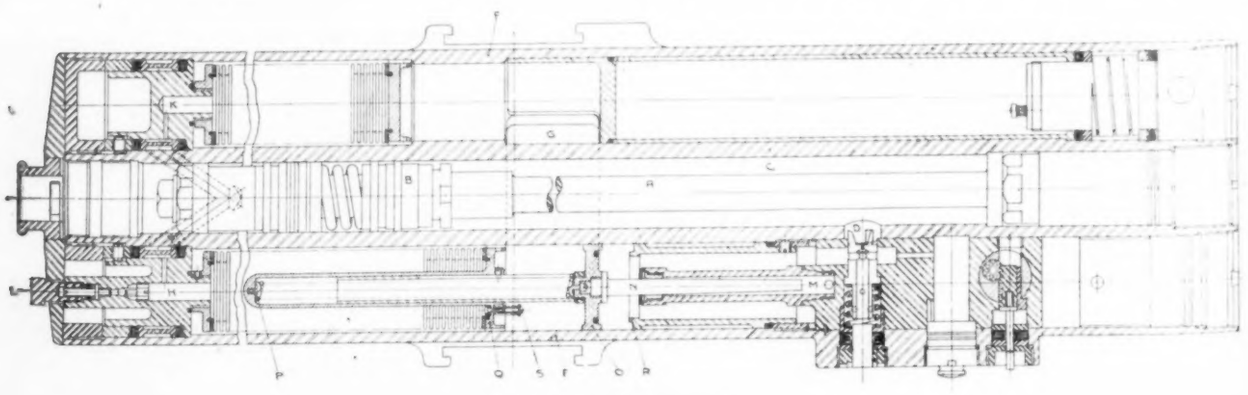


Disappearing Carriage with 16-inch Gun at 30 degrees elevation

These bellows are widely used in heat-regulating devices, packless valves and for other purposes. They can be expanded and contracted many hundred thousands of times and even into the millions, if the limits of movement are well within the elastic limit of the material. Commercial use, however, has not required bellows of as great length as is necessary for our purpose, and this is one serious obstacle to be overcome. A manufacturing process must be developed which will permit forming bellows from long seamless tubes.

The new system was applied experimentally to a 3.3-inch Gun Carriage, and as it was necessary to use the matériel without radical changes, the system could not be applied in an ideal manner; and as the reader will probably note, improvement in the design presented can be made at several points. Before discussing this, however, it may be best to describe the system shown in more detail.

Referring to the figure; the piston rod "A" is attached at its rear end to the gun lug (this connection not shown on drawing). Upon recoil of the gun the rod "A" with its piston "B" moves to the rear and forces oil out of the cylinder "C" through the valve mechanism at "D," thence into the cylinder "E." This cylinder is connected with cylinder "F," the port into "F" being at the point "G," and the exit from "E" being directly opposite. As the oil passes freely between cylinders "E" and "F," these two cylinders are essentially a unit, and cylinder "F" in an ideal design would be omitted altogether if it were possible to obtain a sufficient air capacity in cylinder "E" by enlarging it. The bellows in cylinders "E" and "F" are at all times entirely surrounded by oil, and under static conditions the oil in the whole system is under the same pressure, which is the pressure created by pumping air into the bellows; also under static conditions this pressure



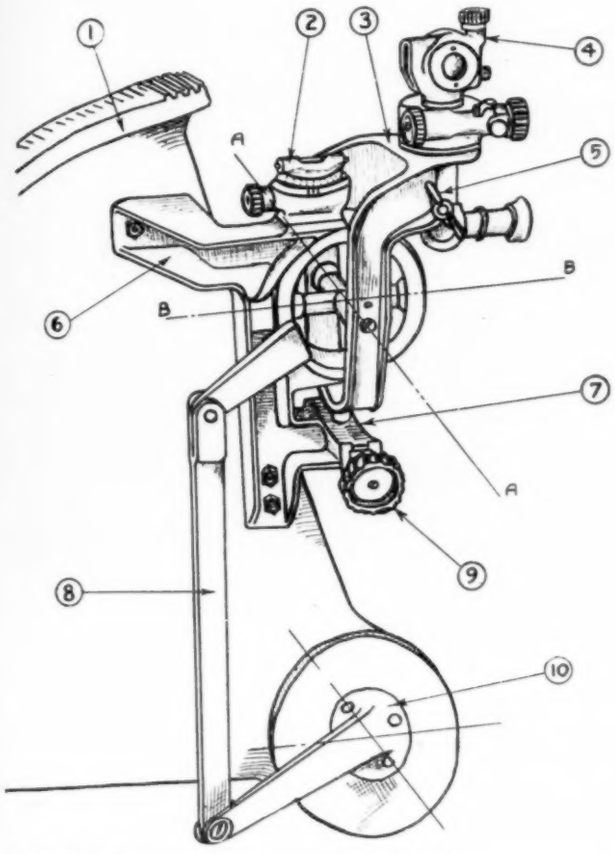
Experimental Recuperator

on the outside of the bellows is exactly equivalent to that on the inside, so that there are no unbalanced stresses acting.

During recoil additional pressure is, of course, created in the recoil cylinder "C," and this pressure is transmitted immediately through the fluid to the oil in the cylinders "E" and "F."

It was at first feared that as soon as the piston "B" began to move a shock wave would be transmitted through the oil somewhat similar to that by which fish are killed, if the ice is struck with a sledge. It was feared that this shock wave might cause collapse of the bellows even before the oil began to perceptibly move. It appears that this action does not occur.

Oil passing through the valve at "D" immediately raises the pressure in cylinders "E" and "F" to that existing in cylinder "C" less the drop in pressure due to friction and loss at the valve and the ports between "E" and "F." The ports between cylinders "E" and "F" are made as large as practicable, so that the two cylinders may act essentially as a unit. To assist further in the equalization of pressure in the two bellows, they are connected at the front end through a channel shown



1. Cradle Rocker
2. Clinometer
3. Sight Support
4. Panoramic Sight
5. Sight Release Knob
6. Main Bracket
7. Cross-Level Slider
8. Actuating Link
9. Cross-Level Knob
10. Sight Link Arm

A-A. Transverse Axis of Sight, Which Shifts According to Deflection in Azimuth

B-B. Longitudinal Axis, Which Remains Parallel to the Bore of the Gun at All Times

at "H" and "K." Through this the air pressure in the two cylinders is equalized. Both bellows are filled at the same time by a pump attached at the valve "L."

It is necessary that the oil shall have free access to all points on the exterior of the bellows, in order to avoid any excessive local pressure, and for this reason the bellows must have ample clearance within the cylinders. This clearance may be provided either by proper adjustment of diameters or by cutting longitudinal channels in the walls.

The gun having fully recoiled, and the bellows being in the compressed state, expansion then begins, and the oil is forced back from the cylinders "E" and "F" through the valve at "D." This valve is, however, practically closed upon counter recoil, and the oil can actually return only through the small pin hole opening at the center of the valve, with the exception that a certain quantity of oil may pass through the opening "M" at the bottom of the regulator buffer, and then through channels not shown on the drawing, it is by-passed around the valve at "D." Near the end of counter recoil, however, the regulator rod in entering the buffer cavity reduces the flow of oil through the opening "M," thus compelling the gun to return gently to its original position, since the opening at the center of the valve "D" is very small, and flow of oil correspondingly slow.

The buffer rod end is attached to the diaphragm "O." This diaphragm is mounted in the bellows head as shown, and under action of the spiral spring "P," it is held at a predetermined distance from the head "Q."

This construction is for the following purpose: If there is loss of oil from the system the pair of bellows under the internal pressure will continue to expand until the void created by the loss of oil is taken up. The rearward movement of "Q" carries the diaphragm "O" with it, and this movement will continue until the packing ring in the diaphragm "O" seats itself on the lip of the sleeve at "R." When this takes place further escape of oil from the cylinders "E" and "F" around the buffers becomes impossible. If, however, for any reason the seal at the lip "R" is not positive, the head "Q" will continue to move until the stem of the poppet valve "S" comes in contact with diaphragm "O." This will open the poppet valve and release air, thus restoring the balance of pressure.

As indicated above, the fact that this system was incorporated for experiment in matériel already available, prevented reduction of the design to the simplest form possible. If it were necessary to use both cylinders "E" and "F" as in the design indicated, probably not much would be gained in the cost of construction over types now in use. It is possible, however, to omit cylinder "F," and thus simplify considerably the system of packing at the left end of the mechanism, which is far from ideal and is not proposed except for the experimental work.

It is estimated that the use of this system would bring with it the following advantages: It becomes no longer necessary to give cylinder "E" a highly finished interior, this cylinder merely being ground. Its exact size is also not of importance. Manufacture of the bellows and its assembly to its closing heads is not essentially difficult, and if these are manufactured in quantity the cost would be relatively low. The parts having once been manufactured, their assembly becomes very simple, and no special skill or knowledge is required in the assembly operations, which are at present a choke point in production.

A mechanism was modified in principle along the lines shown in the sketch herewith, although quite different in some features. It was not possible to secure bellows of sufficient length manufactured out of one piece of seamless tubing. It was therefore necessary to use a number of short lengths soldered together into a tubing 60 inches long. It was not practicable to modify the mechanism to give the full long recoil, and in the test the recoil valve was set for short recoil, and the gun fired horizontally. Starting with a very reduced charge and gradually working up to a full charge, 10 rounds were fired in September, 1919. The bellows was then removed and examined, but did not show any signs of excessive internal or external pressure. Upon re-assembly, 3 more rounds at 5, 10, and 15 per cent overcharge were fired, and the bellows re-examined. One section of the bellows showed slight evidence of external pressure, the convolution being slightly flattened out at a few spots which were apparently of thinner metal than the others. It was anticipated that this might happen, due to temporary local pressure, but it seems entirely possible to eliminate this difficulty by proper construction. It is thought the following tentative conclusions may be drawn from this firing:

(1) No serious disruptive shock wave or other unbalanced force destructive to the bellows is developed.

(2) The metallic bellows will effectively separate the oil and air.

(3) Liberal clearance for the passage of oil forced out from between the convolutions of the bellows must be provided.

(4) In the test made the bellows functioned under greater stresses than it would be subjected to in a properly designed mechanism, and therefore results may be considered promising.

Sights. The following is a description of the sight for the new 75-mm. field matériel recently completed at Frankford Arsenal. The sight automatically corrects both range and deflection for wheels being out of level.

A main bracket is fastened to the left cradle rocker. At its upper end this bracket has a journal, into which a cylindrical turning member is inserted and held transversely, although free to rotate when actuated. Two opposite arms of a cross fit into sockets in this turning member, while the other two arms fit in sockets in the sight support, which holds at its upper end a Panoramic Sight of the latest model. The lower end of the sight support is snugly fitted into a socket in the cross-leveling mechanism. This cross-leveling mechanism is fastened to the main bracket. The sight cross is moved through the same angular distance in elevation as the gun itself, by a link and crank system. The level bubble on the sight support is kept central at all times by means of the knob provided. This insures that the azimuth circle of the

Panoramic Sight is in the true horizontal plane, all angles measured being true angles.

The main bracket, being fastened to the rocker of the carriage, is stationary at all times with respect to the rocker. As angle of site is put on the rocker moves, so does the sight and gun, so that the relative position of the three is not changed. In the rare case when both wheels are on the same level, movement of the cross-leveling knob merely swings the line of sight in a plane perpendicular to the axis of bore of the gun. As the gun is elevated for range, the sight cross is elevated to the same degree. Then cross-leveling throws a twist into the sight support, due to the fact that the support must move in a path restrained by the mechanical limits of the sight cross and the cross-leveling device.

Backlash reduction devices have been provided at all points where this error may creep in.

Caterpillar Mount for 75-mm. Gun. The above illustration shows the new Self-Propelled Caterpillar Mount for the 75-mm. gun and 105-mm. howitzer, Model of 1920, under road test at the plant of the Holt Manufacturing Company, Stockton, Cal. This figure shows a wooden dummy of the 105-mm. howitzer, model of 1920, on the Mount which carries either this howitzer or its companion piece, the 75-mm. gun, 1920.

There has been incorporated in the design of this new mount all of the changes found desirable as a result of the exhaustive tests of the Self-Propelled Caterpillar Mount for the 75-mm. gun, model of 1916, which was the first Caterpillar Mount built for the 75-mm. caliber.

In all Caterpillars noise has been an objectionable feature to the using services, and in the new Mount, effort to eliminate noise and shock has been successfully made by the use of rubber blocks vulcanized to the track shoes, rubber-tired front idlers, track sprockets, track supporting rollers and truck wheels. Shop tests indicate the complete success of the use of rubber. Obviously, the safe operating speed of Caterpillars is greatly increased by reason of the shock-absorbing virtue of rubber.

Removable shields to afford front and flank protection to the personnel riding on the vehicle are provided. These shields are so designed as not to interfere with the elevating or traversing of the piece in firing. Stability is insured by the use of light weight outriggers which instantly drop into position by tripping a latch.

The 8-cylinder motor used in this mount is one of recent design by engineers of the Holt Manufacturing Company. As many standard parts of the 5-ton tractor motor are employed as is possible, in order to facilitate production and supply of spare parts. The horsepower at normal speed is 72, giving a speed of 12 miles per hour as the steady running speed of the Mount. The motor is equipped with both magneto and battery ignition. It may be started either by an electric self-starter, or by hand starter from the driver's seat. The motor is specially designed for operating under water at a depth limited only by the height of operator.

Principal Characteristics—

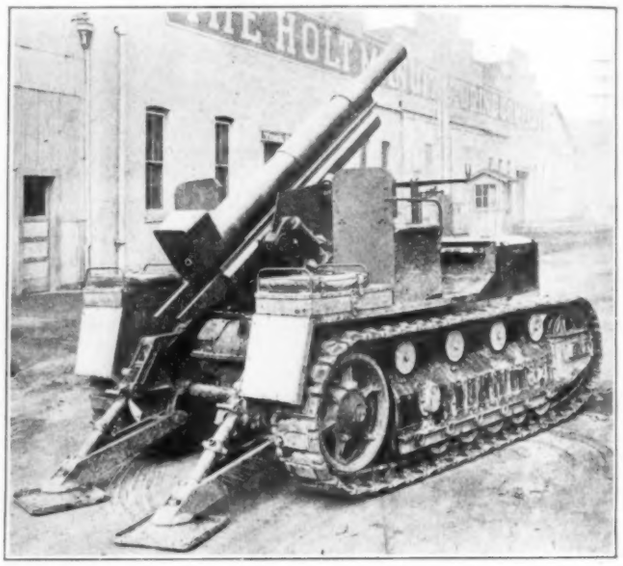
Total weight		12000
Maximum range of gun	yards	15000
Maximum range of howitzer	yards	12040
Maximum traverse		24°
Maximum elevation		70°
Distance from ground to axis of gun	inches	61
Maximum overall length of vehicle	inches	160
Maximum overall width of vehicle	inches	77
Maximum overall height of vehicle	inches	76
Center to center of track	inches	63
Width of track	inches	12
Length of track in contact with ground:		
(a) Minimum contact on hard surfaces	inches	61
(b) Contact length 3-inch depression	inches	108
Approximate ground pressure 3-inch depression	pounds per square inch	5.8
Minimum turning radius	inches	104
Road speed at normal motor speed (1200 R. P. M.)—		
Low speed		2.26 M. P. H.
Intermediate speed		6.45 M. P. H.
High direct speed		11.96 M. P. H.
Reverse speed		1.6 M. P. H.
Maximum speed, motor speed (2500 R. P. M.)		25 M. P. H.

Frankford Arsenal

Musket Sight. Frankford Arsenal has completed the design of a new Telescopic Musket Sight to overcome the objections of the Experimental Board at Camp Benning to the earlier experimental types.

One of the basic principles on which the earlier experimental types were designed was, that to prevent injury to the telescope due to the shock of firing, the mount should be arranged so that the telescope would have a certain amount of movement in the direction of recoil instead of being secured rigidly to the piece. Several samples were made up on this principle; some provided with a spring recuperator for returning the telescope to the firing position and others without it. Another idea proposed by Maj. K. K. V. Casey and incorporated in one of the models was that the body of the telescope should be located on the side of the rifle instead of on the top, an offset eyepiece being provided to bring the line of sight over the center of the receiver. This arrangement had the advantages of permitting clip loading, did not necessitate any alterations to the rifle and permitted the iron sights to be used by simply rotating the telescopic sight down to a position alongside the piece where it was out of the way.

The new sight is of the offset type above referred to, and will possess all of the advantages of this type. In addition, a considerably improved optical system has recently been developed which will be incorporated in it, and which will, it is believed, make this sight superior optically to any of the types either of domestic or foreign manufacture yet tested at Camp Benning. This sight will be of the non-recoiling or rigid mount type, and hence somewhat less complicated than the previous experimental models. It is expected that this sight will be completed in about six weeks, and in the meantime the original "Casey" sight is being given an improved optical system and other minor changes so that a comparative test of recoiling and non-recoiling types may be made.



Caterpillar Mount for 75-mm. Gun and 105-mm. Howitzer

Airplane Observation Instrument. The design of an observing instrument for airplanes for use in Seacoast Range Finding has been practically completed. This instrument is purely experimental and intended to determine the practicability of measuring azimuth angles by means of a magnetic compass, as well as depression angles with a hand instrument in an airplane. The assumption is that the plane itself is out of sight of land, but is being tracked by radio on shore, hence if the location of the target relative to plane can be determined at known intervals, it will be possible to obtain the location of the target relative to the battery sufficiently closely to permit placing a salvo near enough the target for spotting.

The instrument consists chiefly of a pair of ordinary binoculars on which are mounted a compass and a level vial. When these binoculars are depressed to observe a target, the bubble can be levelled by means of a knurled screw, carrying with it the compass which is thus levelled at the same time. An optical system is arranged so that the bubble and the compass reading are visible in the field of view, and it is not necessary to remove the eye from the eyepiece until the scales are to be read.

Field Gun Sights. The design of the sight and quadrant for the 75-mm. and 105-mm. Box Trail Carriage has just been completed and sent to the shop for manufacture. The sight differs from that already made for the 75-mm. and 105-mm. Split Trail Carriage, in that it is less complicated, easier to manufacture, more rugged and yet is as accurate as the earlier models. This sight will automatically correct both range and deflection for wheels being out of level.

The quadrant for this carriage embodies some new ideas in that it is attached directly to the trunnion of the gun and the range is indicated by means of differential gearing actuated by movement of gun relative to rocker.

Anti-Aircraft Sights. The sighting system for the new 3-inch and

4.7-inch Anti-Aircraft Mounts has been designed with simplicity and facility of operation foremost in mind. The absolute minimum of personnel and automatism of functioning element co-ordinate in the establishment of these factors. Only four men are required in giving the proper azimuth and elevation to the gun so that it can be laid to the predicted future position of the rapidly moving target.

The insertion of a differential in the traversing gear mechanism assures undisturbed following of the target by the telescope observer when lateral deflection corrections are given to the gun. Likewise a differential train is used in adding algebraically the vertical deflection corrections to the present angle of sight in order to obtain the future angle of sight, that angle through which the elevation drum rotates. By virtue of this angular movement of the drum and curves of constant fuse range engraved thereon, the operator who elevates or depresses the gun need only set the traveling pointer until it coincides with the curve of announced fuse range. Thus the independent line of sight is retained on the present position of the target irrespective of the gun which is set to the predicted future position of the airplane.

Strong springs take up the backlash between the gear teeth and are so located that they accomplish this in a unidirection. Special interlocks, universal joints and flexible couplings complete the transmission.

As an integral part of the mount, there is applied a gun telemeter and a wind and parallax computer. These permit respectively the determination of fuse range and wind and parallax corrections at the gun emplacement. The fuse setter, which is of the bracket type, but somewhat special in design, is interlocked with the automatic loading device.

Anti-Aircraft Fire Control Instruments. Three experimental anti-aircraft artillery fire control instruments are almost completed. These comprise the field telemeter, observation telescope with wind and parallax dials and the deflection computer. The first named device graphically determines the future fuse range to the target in function of altitude and future angle of sight; the second, besides involving a two power, 15 and 30, observation telescope for distinguishing the target, has a wind and parallax dial permitting the resolution of these corrections; and the last computes the lateral and vertical deflection corrections for the Linear Speed Method as well as the corrected deflections in the case of the application of one type of instrument for the Angular Travel Method of fire control. All three are Battery Commander's Station Instruments, hence the data which they resolve must be either applied to other instruments at that Station or telephoned to the gun emplacements for use.

Range Finders. A comprehensive field test of range finders was conducted at Fort Sill last spring by the Ordnance Department with the co-operation of the Bureau of Standards and Field Artillery. Twenty-three range finders of American and foreign manufacture and having base lengths varying from 80 cms. to 1½ meters were used by 18 observers for a month. During this time approximately 21,000 separate readings were taken. The reduction of observations and statistical study of this large number of readings is not completed but some interesting conclusions have already been demonstrated.

In all cases the readings were taken in groups of 10 with any particular instrument upon a given target by one observer. After the 10 readings were completed the observer either used a different target or instrument, and in this manner took successive sets of readings throughout the period of the tests. The average deviation of the 10 readings from the mean gives a measure of the "dispersion" of the range finders, *i. e.*, the variation in readings arising from inability of the observer to determine exact coincidence in the field of the instrument. This average deviation as first obtained will be in meters and the values obtained for targets at different ranges will not be comparable, since with a given accuracy on the part of the observer and instrument, a mean deviation may be expected to vary as the square of the range. This linear deviation in range can be easily converted into an angular deviation, after which the values are comparable regardless of the ranges for which they were obtained. Of the 18 observers, 10 were men who had recently enlisted in the Army and who were sent directly to Fort Sill by the Ordnance Department after a short training in one of the Ordnance Schools. The other observers were non-commissioned officers from Fort Sill. During the course of the test these 18 observers used all the instruments under approximately similar conditions. It follows, therefore, that if the mean angular deviations as obtained from the groups of 10 readings for each observer, are averaged separately, the resulting final average angular deviations are indicative of the precision with which the different observers can determine coincidence.

While the determination of the angular deviation is most necessary when a number of observations taken with different instruments or at different ranges are to be compared, the user of the instrument is primarily interested in the deviations expressed in terms of range. With this thought in view the following table has been prepared.

The numbers in the first column are arbitrary numbers assigned to the different observers. In the second column is given the average angular deviation. In the third column the angular deviation has been converted into a range error and this column therefore gives a mean deviation in meters which may be expected when the observer uses a one-meter base range finder on a target at 4,000 meters. In the fourth column corresponding values at 8,000 meters are given. These values are, of course, based on the average angular deviation as given in the second column.

Observer	Mean Angular Deviation in seconds.	Mean Linear Deviation in meters. Range=4000 m.	Mean Linear Deviation in meters. Range=8000 m.
1	1.5	116	464
2	1.6	124	496
3	1.6	124	496
4	1.6	124	496
5	1.6	124	496
6	1.7	132	528
7	1.7	132	528
8	1.7	132	528
9	1.8	140	560
10	1.9	147	588
11	1.9	147	588
12	1.9	147	588
13	2.0	155	620
14	2.0	155	620
15	2.1	163	652
16	2.3	178	712
17	2.3	178	712
18	2.6	202	808

The exact significance of this table should be noted. The values of the deviations are based upon readings taken by the observer with 23 different instruments. It is to be expected that the reader could better his record if he only used the best instruments selected from the 23. With this proviso, the last two columns represent average deviations of 10 readings from the true range, which may be expected when a one-meter base range finder is used, upon which the infinity adjustment is correctly made.

It is interesting to note that the mean deviation for observer No. 18 is almost double that for observer No. 1. In other words, observer No. 1 with a one-meter base range finder would be almost as efficient as observer No. 18 with a two-meter base instrument. This illustrates clearly the necessity for a careful selection of observers and their careful training if satisfactory results are to be secured with the self-contained range finder.

Rock Island Arsenal

75 mm. Field Matériel, Model of 1920. The 75-mm. Gun, No. 1, model 1920 (with sliding block) was received at the arsenal and assembled to the carriage without fitting. The following data in regard to this gun mounted on carriage No. 1, model 1920 (split trail), have been secured:

With the trails locked together and the traveling lock assembled to the cradle the elevation is 17 degrees and 30 minutes. With the cradle resting on the traveling lock and lock bolt released, the gun may be traversed in either direction 200 mills. With the trail spread the full traverse of 15 degrees to the right or left and elevations between minus 4½° and plus 80° are secured. Theoretically the weight, which must be lifted at the end of the trail in limbering the field piece of this caliber, should be such as can be accomplished by two men. The weight at the center of the trail handles of this combination is, in the position indicated above, 254½ pounds, and at the height of limbered position 139 pounds. The weight on the pintle of the limber is about 125 pounds. The included turning angle of the gun carriage limber, model 1920, with the 75-mm. gun carriage, model 1920, is 102 degrees, corresponding to a mean turning radius of limber of about 9 feet with the inside wheel of carriage turning on a circle of 20-inch radius.

A feature of the design of this limber is that the hand rails and other projecting attachments which so often interfere with compact storage in vehicles of this nature, may be removed and stored or shipped in the chest.

The actual weight of the assembled gun and carriage is 3,660 pounds, and of the limber fully equipped 1150. With the carriage limbered the weight on the wheels of the carriage is 3,534, on the wheels of the limber 1,270, and on the neckyoke 6 pounds . Both carriage and limber are at present equipped with the same heavy rubber-tired wheels (weight of each wheel 295 pounds). It is the understanding that the department is considering a reduction of weight of the limber wheels.

In the gymnastiqueur tests of the recoil mechanism of this carriage the first results were unusually good. In the gymnastiqueur the gun is mounted on the cradle and retracted at zero and 35 degrees elevation and allowed to return freely into battery under the action of the air pressure cylinder. The counter-recoil action at a temperature of 70 degrees was very satisfactory, showing the design to be excellent and manufacture of the mechanism carefully done.

Proof-firing of this gun and carriage was started December '22 with an outside temperature of 34 degrees. At this temperature the oil in the recuperator was viscous and heavy, and the firing tests were to determine the safety of the gun rather than of the functioning of the carriage. On December 23, with an outside temperature of 26 degrees, 2 rounds were fired, 2 pounds, 9 ounces of the powder supplied for the first round increased to 2 pounds 11 ounces for the second. The resulting powder pressure was 32,260 and 34,500 respectively. At 34,500 pressure a muzzle velocity of 2,104 feet per second was secured. The projectile used in this firing was a square or blunt end slug, weighing 15 pounds, especially provided for proof-firing purposes. The length of recoil at the 5th round with practically a service charge was 23 inches and the carriage was returned to the shops for adjustment of the recoil mechanism and a survey for deformations of the carriage. In further firings, recoil and counter-recoil velocimeter records and indicator cards of the interior pressure of the recoil cylinder during the recoil will be taken.

For proof-firing at temperatures such as obtain at the present time, zero degrees to 15 degrees, it is the intention to substitute for the heavy Oleonapthe a blend having the same viscosity at about 15 degrees above zero as Oleonapthe has at 70 degrees. Thus, in firing at low temperatures, the recoil action will more truly represent the normal.

The recoil velocimeter record is the wavy line traced by one prong of a tuning fork upon a steel ribbon coated with lamp black and drawn to the rear under the electrically vibrated fork by the gun in recoil. The vibration of the fork per second being known, the distances from crest to crest of the waves in the record give the velocity of recoil at any point. Similar record is taken of the counter-recoil on a blackened ribbon attached to the gun, the vibrating needle being mounted on the carriage and set vibrating by the gun at the end of recoil. Its record is made as the gun returns to battery. The interior cylinder pressure record is taken on a Tabor indicator of the familiar steam engine indicator type, the cord of the drum of the indicator being attached to the gun, which thus turns the drum in recoil as the pressure moves the pencil to trace the record. This instrument is inclosed in a sheet steel box to protect it from the blast of discharge.

An interesting comparison between the weights of guns and recoil mechanisms of recent types is given in this table:

	75 mm. gun, model 1920, on carriage, model 1920.	75 mm. gun, model 1916, on carriage, model 1916 (spring counter recoil).	75 mm. gun, model 1916 M1, on St. Chamond type (pneumatic recoil mechanism).	75 mm. gun, model 1897 (French), on recoil mechanism (pneumatic), model 1897 M1.
Weight of gun (sliding block)	1242	764	970	1015
(screw block)	1225			
Weight of other parts tipping in elevating	684.5	544	395	305
Total	1926.5	1308	1365	1320
Ratio weight of other tipping parts to gun—per cent	55	71.2	39.5	30

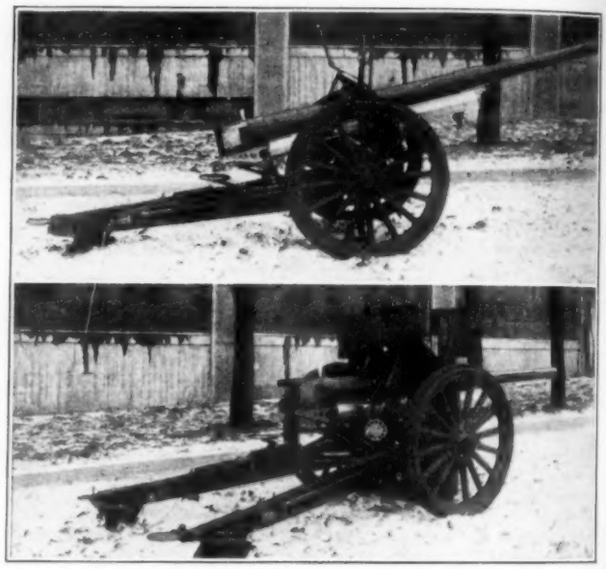
Note.—In the weight of the tipping parts of the model 1920 are included movable shields weighing 97 pounds. Deducting this the ratio of recoil mechanism weight to gun weight becomes 47.3 per cent. In the model 1916 the high percentage is in part accounted for by the addition of weight to recoiling parts to shorten recoil to make up for the considerable reduction in weight of gun. As, however, the model 1920 gun has also been designed at minimum weight, the comparison with the model 1916 would indicate a considerable saving in weight of the pneumatic mechanism over springs.

Recuperator Storage. The hydro-pneumatic recuperators for 75-mm. gun carriage, model 1897 (French), are stored in accordance with Ordnance Field Service Bulletin No. 27, which provides that the recuperators for these carriages may be stored either separately or assembled to the carriage. At Rock Island Arsenal these recuperators are disassembled from the carriage and stored in racks built for the purpose, as shown in illustration on page 198. These racks are built in such a manner that the recuperator is properly supported without fear of the distortion of any part and so that the recuperator is readily accessible for inspection and can be readily removed for shop tests. All serviceable recuperators in store are those which have been thoroughly overhauled and which have performed satisfactorily under the prescribed shop tests. These recuperators are properly charged with nitrogen and oil and all exterior exposed surfaces are slushed with a non-fluid slushing oil.

The detection of any loss of nitrogen is made possible by sealing up the nitrogen end of the recuperator with grease in such a manner that any leakage which occurs is evidenced by the presence of bubbles in the grease. In all inspections which have been made to date no leakage of nitrogen has been discovered.

Leakage of oil is detected by an indicating finger, which is made a part of the recuperator assembly for this purpose. After the recuperators had been in storage for some time it was discovered that, in spite of the precautions taken to insure that all valves were as tight as possible, a slight leakage of oil occurred at field filling valves and oil gauges. This leakage, if allowed to continue, passes the point where the reserve oil is exhausted and results in a void occurring in the recuperator cylinder and corrosion of the exposed surface would eventually result. Fortunately, however, it is possible to readily detect this leakage and it is a very easy matter to pump in additional oil to overcome it.

The instructions covering storage and maintenance require that ten recuperators be selected at random during each six months' period and that they be dismantled completely for a thorough inspection. The first inspection of this kind made since July 1st was conducted in November, when ten recuperators were drawn at random, five being from a lot of



75 mm. Gun, Model 1920, on Carriage No. 1, Model 1920
Above: Carriage unlimbered, Traversing Lock engaged
Below: Right side view; firing position 0 degrees elevation

555 made at this arsenal and five from 2,300 of French manufacture which were overhauled and repaired at this arsenal. Before disassembly the nitrogen pressure was taken by a gauge and found to be practically the same as when the recuperators were originally stored. Every part of the recuperator was then disassembled and given a minute inspection to detect any deterioration that might have occurred, especial care being taken to see that the different springs used in the various assemblies were not broken. With the exception of some discoloration caused by the leather and rubber packing, all parts were in splendid condition. This discoloration is evidently the result of some form of corrosion which might in time affect the operation of the recuperators. In order to eliminate this possible source of deterioration, experiments are now being conducted with a view of determining if some metallic packing cannot be substituted for the rubber and leather packings now used.

It will be observed that the method of storing recuperators at Rock Island Arsenal not only results in a great saving of space, but also renders it possible to make the periodic inspection at a minimum expense. If the recuperators were part of the completely assembled carriages, it would be necessary to remove the guns and shields from such carriages at the storehouse and transport the recuperators separately to the shops for disassembly. After return it would be necessary to again completely assemble the carriages. With the method of storage adopted, it is a simple matter to remove the recuperators from the racks, load on a truck and transport to the shops. The selection of the ten recuperators at random is also greatly simplified, as all recuperators are equally accessible, whereas if they were stored assembled on the carriages this would not be the case. Inspection of recuperators for loss of oil is also greatly simplified, as the inspector confines his work to an area of approximately 3,900 square feet, whereas if the

75 mm. Gun, Model 1920, on Carriage No. 1, Model 1920
Rear view 80 degrees elevation; 0 degrees traverse

recuperators were on their carriages he would be obliged to cover an area of approximately 47,000 square feet.

Rock Island Arsenal Hydro-Electric Station. The Ordnance Department possesses the distinction of having at Rock Island Arsenal the largest low head hydro-electric generating station in the world operating on a 12-foot head of water and under. The generating units consist of eight Westinghouse alternating current generators, each direct connected by a vertical shaft to an S. Morgan Smith water turbine. The generators are of the 3-phase, 60-cycle, 2400-volt alternating current revolving field type and have a rating of 430 Kv-a capacity at 80 per cent power factor. The water turbines are of the reactive type and have a rated output of 550 horsepower at 12-foot head.

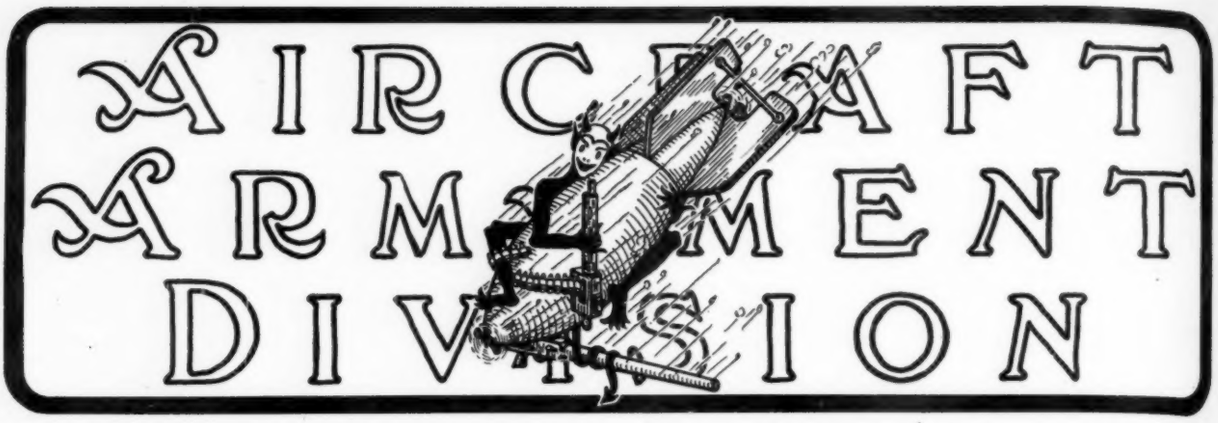
Excitation is provided by two direct current Electric Machinery Company's generators, shunt wound, 125 volts, 130 Kw. capacity, each direct connected through a vertical shaft to an S. Morgan Smith water turbine of the reactive, enclosed scroll type. For excitation in case of emergency there is also provided a 100 Kw. motor generator set.

The eight generating units and the two water turbine driven exciting units are governed by Woodward Oil Pressure Governors, the generating units being operated at 72 r. p. m. and the exciting units at from 105 to 120 r. p. m.

For the proper control of the above-mentioned equipment and for the distribution of the power produced, there is installed a 37-panel switchboard, complete with ammeters, voltmeters, wattmeters, power factor indicator, frequency indicator, relays and control switches. Oil break switches on the generator, feeder and generator field circuits, which are located on a sub floor, are remote controlled by switches on the main switchboard. In the construction of the switch and bus room a double bus arrangement was installed, with interlocking switches, enabling the load to be transferred from one bus to the other without interruption of service. Two busses are maintained on account of the necessity of procuring power from an outside source at certain periods of the year when needle ice, ice gorges or flood stages prevent the plant from producing its full output. In such cases the arrangement of the switches and busses is such that the various feeders may be so connected that certain ones will be supplied from the arsenal station while others will be supplied from the outside source.

The current produced by the generating units is delivered direct to 2300-volt circuits and transformed to 550, 440 or 110-220-volt circuits in the various shop buildings where electric power and lighting are used. Power delivered from the outside source is delivered at 4800 volts, 2-phase, 4-wire, and transformed to 3-phase, 3-wire, 2300-volt through two 1000 Kv-a transformers, Scott connected. The transformer equipment is protected by two sets of differential relays for operation in case of line or transformer trouble.

"Christie Self-Propelled Mount for 155-mm. Gun Climbing 45° Grade



Some of the development work which is being undertaken by the Aircraft Armament Division, Office of the Chief of Manufacture, Ordnanre Department, at this time, is as follows:

Bombs.

Under bombs every effort is being made to develop proper "delay" elements for use with new nose and tail fuses. The testing of new fuses, the development of which was initiated shortly after the signing of the Armistice, has been considerably hindered by the difficulty encountered in obtaining proper delay elements to be used with them. During the past month tests of the delay elements have been held in which the longer delays did not give entirely satisfactory results. It is possible that these will function satisfactorily with the new tail fuses, but the tests indicated that erratic results might be expected when they are used with the nose fuses. It is believed, however, that with the new design of fuses, even if the long delays are not obtained, better results will be secured than with the old design of fuses. It will be remembered that the new fuses are armed by the wind vane, can be easily assembled to the bomb in the field, and have interchangeable primer detonators.

Developments have been initiated on entirely new nose and tail fuses. These will be somewhat different in principle from those now being tested. The specific problem of designing and developing these fuses has been assigned to Frankford Arsenal and during the past months the Arsenal has submitted designs which have very promising features. An additional safety feature has been included in these designs, of holding the detonator from in line with the primer and having it move into place only after the bomb has been released from the airplane. In the safe position the detonator, even though it should function, cannot detonate the booster. The delay elements have been combined in these fuses so that no assembling of primer detonators and fuses has to be undertaken in the field. With these fuses the desired delay is set before the airplane leaves the ground.

The manufacture of the heavy case bombs is progressing at Watervliet Arsenal, although this work has been considerably delayed through the failure of subcontractors to make deliveries on time. These bombs weigh approximately 100 pounds, 250 pounds and 550 pounds, the cases being made of four kinds of metal, viz., cast iron, malleable iron, semi-steel and cast steel. In the development tests, which will be held at Aberdeen Proving Ground, Maryland, it is expected to find out which metal gives the best results and with this known, additional bombs of the most effective metal will be produced for functioning tests.

Designs have just been completed of the new 100-pound, 300-pound, 600-pound and 1100-pound Demolition Bombs of the thin wall type. These bombs are similar to the types developed during the war, except that provision has been made for the new fuses and the stabilizers have been designed so that they can be shipped disassembled from the bomb and can be easily attached in the field. These designs have been sent to McCord & Company, of Chicago, Ill., the A. O. Smith Corporation of Milwaukee, Wis., and Maj. J. H. Barr of the Remington Typewriter Company, New York City, together with letters requesting comments and suggestions for their improvement. While it is the policy of the War Department, in accordance with statutory restrictions, to concentrate as much work as possible at Government Arsenals, it is fully realized that in time of war the bulk of manufacturing work must be done by the private plants of the country. Consequently, an attempt is being made to lay down all designs with this in view and the comments of private manufacturers will be of considerable assistance in putting the designs of the new series of Demolition Bombs in the best form for quantity production. It is anticipated that the bombs will be manufactured at either Rock Island Arsenal or Watertown Arsenal and a representative from the Aircraft Armament Division, Ordnance Department, will visit these Arsenals within the month to go over the designs with the engineers of the Arsenals and decide on any changes which might simplify manufacture.

A series of Fragmentation Bombs are being manufactured at Watervliet Arsenal with cases of malleable iron, cast iron, semi-steel and cast-steel, which, when completed, will undergo development tests at Aberdeen. The metal which gives the best results will be specified in a new order for Fragmentation Bombs required for functioning tests.

Of Incendiary Bombs, there are being manufactured at Frankford Arsenal, several thousand 8-ounce Incendiaries, which are similar in design to the British B. I. Bombs. Containers for these bombs are also being manufactured at that plate. These bombs will be loaded by the Chemical Warfare Service, at Edgewood Arsenal, Md., some, however, being loaded as Smoke Bombs. They will be tested at Aberdeen, and, if satisfactory, several thousand will be manufactured for service test. Considerable progress has been made in the development of a modification of the old Mark II Incendiary Bomb. This modification covers the addition of a nose fuse and a new tail fuse. The tests, to date, indicate that this bomb as modified will give satisfactory functioning and it is believed that for an intensive type of Incendiary Bomb it will be as satisfactory as any developed during the war.

Ballistics of Bombs.

Some progress has been made on the ballistics of bombs, and exhaustive program has been drawn up covering the testing of r[illegible] in the wind tunnel at the Bureau of Standards. This program [illegible]s the testing of bombs of various contours and some models of actual service bombs. It is hoped, in these tests, to obtain the best form of bombs, to get some relation between the results obtained by actually dropping bombs and the results obtained in the wind tunnel, and to ascertain the best method of controlling the terminal velocities of bombs.

Progress has been made in the development of equipment to be used in obtaining the ballistic data on bombs. This equipment covers moving picture cameras, suitably mounted in airplanes, which can photograph a bomb in its flight and the reflection of the airplane as the plane flies over still water. A series of crosses have been installed in the water around Aberdeen, which are also photographed at the time that the bomb is falling. The films can be scaled and data obtained which is sufficient for all ballistic computation. It is hoped to obtain a number of ballistic films, before ice forms, to supply the Bureau of Standards with sufficient material with which to carry on their ballistic computations during the winter.

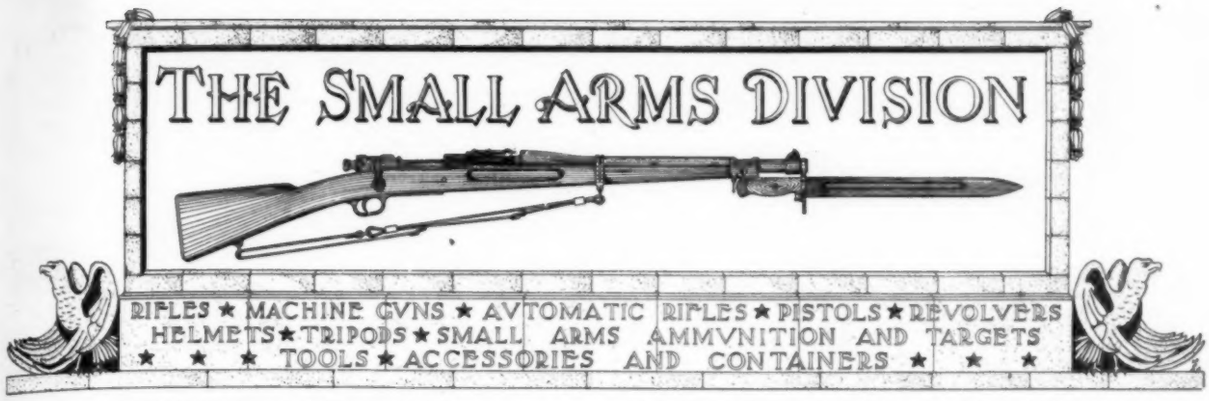
Bomb Sights.

Gratifying progress has been made in the development of Bomb Sights at Frankford Arsenal. Capt. E. J. Loring, who was with the Aircraft Armament Division, Ordnance Department, during the war, is at Frankford directly associated with this work. A modification of the French Michelin Sight has been completed for sometime and is awaiting test. Another modification of the Michelin Sight has been developed which will be established by a gyroscopic stabilizer. Two of the latter have been completed at Frankford Arsenal and when the stabilizers, which are being manufactured at the Sperry Gyroscope Company, are completed, the Sights will be available for test. A new Sight is under development which will allow bombing in any direction of flight. A study has been made of all Bomb Sights received from abroad, together with their stabilizing elements, with the object of assisting in the development of our material and, in addition, tests are being held of every available Sight in order to form a basis of comparison for new Bomb Sight development.

Bomb Racks.

Under Bomb Racks a new rack has been designed and developed and is now under manufacture to replace the old Mark V Release Mechanism. A number of these racks are being manufactured and will be shipped to Air Service organizations to be used in an exhaustive service test. Racks have been developed and manufactured for an order of Martin airplanes being manufactured by the Glen L. Martin Company. These racks are similar to those developed for the Handley-

Continued on Page 231


THE SMALL ARMS DIVISION
RIFLES ★ MACHINE GUNS ★ AUTOMATIC RIFLES ★ PISTOLS ★ REVOLVERS
HELMETS ★ TRIPODS ★ SMALL ARMS AMMUNITION AND TARGETS
★ ★ ★ TOOLS ★ ACCESSORIES AND CONTAINERS ★ ★ ★

SPRINGFIELD ARMORY NOTES

COLORING AND FINISHING OF SMALL ARMS PARTS

The problem of giving a satisfactory finish to small arms parts has many possible solutions, but when consideration is given to all the factors involved such as cost and rate of production, relative durability and resistance to corrosion, the tempering effect of heating processes, etc., it is often difficult to determine the best process for a particular piece. It can readily be understood that different manufacturers have different views regarding the desirability of the same finish. What may be considered desirable as a finish for a commercial arm may not be satisfactory from military considerations. For example, a shiny blue or a bright mottled finish may be popular with the inexperienced purchaser of shot guns or revolvers, but a heavier dull black finish is obviously preferable for strategic reasons in military use.

The relative resistance to corrosion of the different finishes is a question over which no end of controversy has existed, and until recently very little reliable comparative information has been available.

The different methods and their numerous variations can be conveniently classified as (I) Solution Methods and (II) Heating Methods. The latter are limited in their application to heat treated pieces, for tempered pieces can only be heated to a limited degree, unless it happens that the tempering and coloring can be combined in one operation. Practically all these processes consist of giving the meta a uniform and absolutely continuous coating of an iron compound. The latter is electro-negative with respect to iron and chemically relatively inert, and like all such coatings if the continuity of the surface is broken corrosion is accelerated where the iron is exposed and proceeds faster than it would if the electro-negative substance was absent. The depth of the coating has a great deal to do with the appearance and corrosion resisting qualities of the finish. It is a matter of common observation that very thin coatings of this nature are light in color, giving a metallic lustre, and rust more readily than the heavy dull black finishes. The depth of finish can generally be controlled by regulating the details of application of the process, though some of the "blue" finishes cannot be made heavy enough to give good protection from corrosion.

I. Solution Methods.

The oldest, and until recently, the most widely used process, is the so-called "browning" method. This is still used where large scale operations do not warrant the changes of equipment, etc., required by the more efficient new processes. In this method it is necessary to repeat the processing at least three times to get a satisfactory coating, making the operation a lengthy one. When properly carried out the resulting color is very good. In applying this process to rifle barrels, for an illustration, the bores are oiled and the ends plugged. The pieces are then washed in soda solution (or a suspension of lime) rinsed in clean water and carded with a wire brush. As in all of these processes, it is very important to have the surface absolutely clean before processing. The browning acid is then applied and allowed to dry after which the pieces are placed in a moisture cabinet for two hours at a temperature of 145° F. The proper humidity is attained in these cabinets by periodic spraying. After removal from the cabinet the pieces are rinsed in boiling water and then carded on a wire brush. The application of the browning acid, steaming, boiling and carding are repeated two more times. After the third carding the pieces are dipped in oil. The composition of the browning acid is:

250 cc. grain alcohol,
40 cc. nitric acid (con.),
2 cc. hydrochloric acid (con.),
2000 cc. water (soft water, distilled if necessary),
28 grams mercuric chloride,
280 grams ferrous chloride,
14 grams copper sulphate.

Many secret formulas, claiming superior qualities, exist for this solution, the chief variation among them being in the form in which the chlorides and nitrates are present and in the chemical names used to designate the above essential ingredients. As the process is a chemical one of producing a uniform layer of rust and changing it to a stable coherent oxide, it is naturally affected by atmospheric conditions of moisture and temperature. In the carrying out of the process on a large scale it is therefore necessary to control these conditions in the rooms where the process is carried on as well as in the process cabinets. The slowness of this process is apparent from the above description. The coating obtained is not as rust proof as is desirable. Both of these objections are overcome to a certain degree in the Parkerizing process.

The Parker finish gives a very satisfactory resistance to corrosion on all small arms components. It is not as attractive looking a finish as some of the others, but if great care is given to details of application of the process a good uniform dull black can be obtained. This finish tends to give a grayish color. This may be more or less covered by proper oiling, or, if an oil-flashing treatment is given after the Parkerizing, a fine black color can be obtained that is even more rust proof than the regular Parkerized finish.

Parkerizing is a development of the Coslett process patented in 1907, and consists of the formation of insoluble phosphates on the surface of the pieces treated. The process is licensed to users who are furnished with instructions for using the solutions required. The phosphate coating given by this process is somewhat more voluminous than the oxide given by the browning process, and the loose deposit formed on small pieces is sometimes objectionable and a hindrance to their proper working. For larger, not too close-fitting pieces, the coating is very satisfactory, adhering firmly and resisting corrosion better than the oxide coating. The process consists of immersing the pieces in a weak solution of iron phosphates at 210° F. until the evolution of gas resulting from the surface reaction ceases, a period of 40 minutes to 2 hours' time, depending on the condition of the solutions and the size of the pieces. It is important to maintain the processing tank at the proper strength with respect to acidity and degree of oxidation. This is done by simple chemical test, and the experienced operator can detect changing conditions from the appearance of the work.

A very important factor in the color of the finished work is the condition of the surface before Parkerizing. Too highly polished pieces do not give a good color, and the presence of the slightest scale from forging or hardening will result in spotty work. A fairly coarse sand-blasted surface will give the blackest appearance, evidently the rough matted condition of such a surface influences the light absorption and apparent blackness of the pieces. A great many Parkerizing troubles have been overcome by experimenting with the conditions of the surfaces before processing, and it is always well to try all reasonable variations of sand blasting, sand tumbling conditions, polishing abrasives, and pickling variations of time and acid strength before establishing the exact procedure to be followed in treating any particular piece. This holds true to a certain extent with all other finishes.

II. Heating Methods.

The method known as "nitre bluing" gives a very quick and inexpensive but rather superficial oxide coating and has the limitation of other heating processes of not being applicable to heat-treated parts that cannot be tempered to 800° F. Potassium nitrate is fused in a cast iron crucible and about 5 per cent of manganese dioxide added. The pieces are immersed in this solution at about 800° F. for a few minutes, the time required varying with the size of the piece, and then quenched with water to remove the nitre. By proper regulation of the time and temperature very beautiful colors can be obtained. These are not of any great depth and are not efficient in protecting from rust. Sometimes these finishes are lacquered for further protection.

Practically the same colors can be obtained by "charcoal bluing." This method consists of heating the pieces on a pan of charcoal over an open flame or in a muffle furnace. This is a slower and more expensive method than the nitre bluing, requiring considerable skill in order to get the desired color, and has no compensating advantages.

On a large scale efficient bluing or blacking can be carried on in the Carbonia gas heating machines. By rotating cylindrical drums properly charged with the work, and the correct proportion of oily charred bone, and heating to a proper temperature large numbers of pieces can be uniformly treated to any desired blue or black. This process is now quite generally used for revolver and pistol parts. A rack containing 100 revolver frames can be given a deep black finish in about seven hours time. A temperature of about 700° F. is used, a lower temperature being used for a bluer finish. The pieces are quenched in oil after treating. The quantity of bone and oil in the charge has to be carefully regulated. Smaller parts can be treated in larger quantities with corresponding lessened cost. One operator can handle several furnaces, making the cost relatively small for large scale production. As in the other finishes, it is important to have the work properly polished and cleaned before treating and the temperature has to be very carefully controlled to get uniform color. This finish has an excellent appearance and good rust-proofing qualities.

Small screws, etc., are often given a black finish by "packing" in charcoal and heating to 1500° F. and quenching in oil.

There are a number of commercial blacking finishes giving a magnetic oxide coating. These are all modifications of the Bower-Barff process and consist of heating in steam or hydro-carbon gases at temperatures from 1300° F. to 1500° F. These coatings are very satisfactory for heavy pieces that can stand the relatively deep oxidation and the effect of the high temperature.

An electrolytic method has been developed abroad, but has not been used to any extent in this country. It consists of placing the pieces to be blacked in a hot alkaline solution containing iron salts and making the pieces to be blacked act as cathodes for about two minutes. While thus acting, the article is both cleaned and plated with electrolytic iron. The current is then reversed and the pieces act as anodes for six to eight minutes, during which time a black oxide coating is formed. A dip in a hot caustic soda and sodium nitrate solution followed by oiling completes the process.

It is often desirable to "patch" a "browned" or black finished surface without refinishing the whole piece. There are several solutions for doing this. If properly handled a very good adherent black can be obtained by first "coppering" the surface and then treating with a sulphide solution. The copper solution is made up as follows:

75 gms. copper sulphate,
10 cc. sulphuric acid (1.84 sp. gr.),
500 cc. water,

The sulphide solution is made by dissolving sodium sulphide in water until a saturated solution is obtained, adding 250 grams of flowers of sulphur per liter of solution and allowing to stand for 24 hours. The solution is then made up to working strength of 1.142 sp. gr. at 60° F. with water. In applying, it is necessary to get a good coating of copper by dipping in the copper solution. (Too thick a coating will rub off easily.) Wipe off this solution and dip piece in the sulphide solution, wipe off the excess, rinse in hot water, dry and oil. This method is use dto very good advantage to color the ends of cocking pieces after the polishing made necessary on riveting to the firing pin.

Another solution that can be recommended for patching has following composition:

1.5 gm. selenious acid,
2.5 gms. copper sulphate,
1 cc. nitric acid (conc.),
250 cc. water.

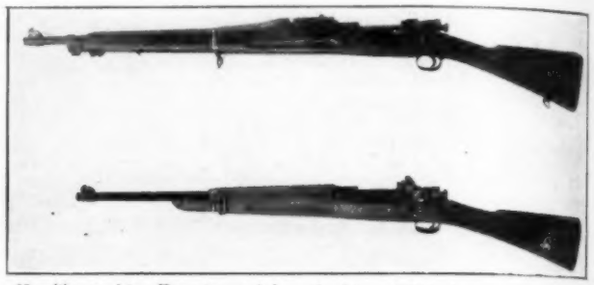
The selenious acid is rather expensive and difficult to obtain, but the method is useful where occasional patching of finished surfaces is necessary.

EXPERIMENTAL CAVALRY CARBINE

Springfield Armory has completed an experimental Cavalry carbine and shipped it to The President of the Cavalry Board at Fort Riley for test. The carbine has a 20-inch barrel with a short stock. It is fitted with special sling swivels on the left side in order that it may be carried slung across the Cavalryman's back in such a position that the bolt handle will not cause interference.

The carbine is fitted with a Lyman No. 48 sight modified so as to show graduations in yards instead of in minutes. Each turn of the elevation screw equals five minutes. The knurled head on the top of the elevation screw is divided into five divisions, each of which is equivalent to one minute. One turn of the windage screw is equivalent to four minutes or approximately one point of windage. Both the windage and elevation screws click for each minute of adustment.

It is found that the reduction in length of the barrel to 20 inches, instead of 24, reduces the muzzle velocity approximately 100 feet. The standard muzzle velocity is 2700 feet per second while the muzle velocity of the new weapon is 2600 feet per second.



.30 caliber carbine, Experimental. Length of barrel 20 inches; weight 8 Pound
Service rifle shown for comparison

Shortening the barrel had the effect of noticeably increasing the muzzzle flash, especially when firing the rifle in a dim light.

It is found that the rifle handled very easily and is exceptionally well balanced. The recoil is not noticeably greater than that of the service rifle. The accuracy of the sample was found to be excellent.

The new hydro-electric plant at the Water Shops consisting of a 375 K.W. 550-volt 3-phase 60-cycle generator, direct connected to a vertical water wheel, has been placed in successful operation. It has been carrying the shop load since December 16, 1920, and thus relieving the shop of a cost of approximately $40.00 per day, which would be necessary for purchasing electric power from the city source. As long as sufficient water is available, the hydro-electric set will furnish enough power to carry the entire shop load on a peace-time basis.

Lieut. George Raeder, Norwegian Artillery, visited this Armory on November 11, 1920, to acquaint himself with the organization and work of the Ordnance Department.

Capt. Walter T. Gorton, Ord. Dept., U. S. A., visited this Armory on November 29, 1920, in connection with the development work of the Caliber 37 mm cannon.

Major Figueroa and Captain Bianchi, accompanied by four non-commissioned officers, F. Hille, R. Valenzuela, G. Juarez and A. Rojas, Chilean Army, attached to the Chilean Ordnance Commission, now in the United States, visited this Armory recently.

Maj. Herbert O'Leary, Ord. Dept., U. S. A., Chief, Small Arms Division, Ordnance Office, visited this Armory on December 29 and 30, 1920.

Lieut. Forrest C. Shaffer, Ord. Dept., U. S. A., has been transferred to Fort Bliss, Texas.

FRANKFORD ARSENAL NOTES.

Alloy Steel.

The manufacturers of Small Arms Ammunition during the War period will undoubtedly recall the enormous cost of dies and punches, and the idle hours of machines by reason of time consumed in changing dies.

At the Frankford Arsenal certain experiments now being made in the manufacture of dies and punches will, from present indications, result in an enormous saving in the manufacture of dies and punches used for various purposes in the manufacture of Small Arms Ammunition.

The lead press die for the extension of lead wire has heretofore been made of the best grade carbon steel. This die lasted only two or three hours at best. It was necessary to renew the die on an average of three times daily, each change shutting down the press and requiring a mechanic about half an hour to make the change. Recently a die for this same lead press was made from an alloy steel with the result that this die has now been steadily in use for ten days and is still serviceable.

A primer cup punch, formerly made from the best grades carbon steel would last from two to three hours on the primer cupping operation. It has been found that the same punch made of an alloy steel will last at least ten days.

A primer cup die manufactured from the best grade carbon steel for use in the manufacture of a primer cup for .50 caliber ammunition failed under the strain. A die was manufactured from an alloy steel and at the present time is still in good condition.

It has not bet been determined what further dies and punches can be satisfactorily made from alloy steel and utilized in the manufacture of Small Arms Ammunition. Experiments with alloy steels are being made on other difficult operations to increase the life of the tools.

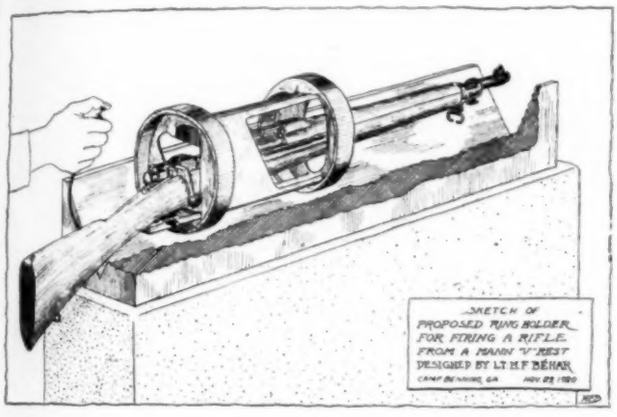
A Novel Type of Machine Rest

By

MANOEL F. BEHAR
Member, A. O. A.

Everybody interested in rifle shooting has heard of the machine rest, in which a rifle is clamped for accuracy firing. It would surprise most gun cranks, however, to be told that so great a degree of expertness is needed to operate one of those apparently simple devices that throughout the United States there are fewer than a dozen men capable of obtaining smaller shot-groups from the machine rest than those made on targets by any one of the thousands of expert riflemen using a good telescopic sight under favorable conditions of light and wind.

The present type of machine rest is as nearly perfect as it can be. The trouble is not one of careless design, but simply that a machine rest is like a carburetor—it takes an expert to set it right. That is because when a rifle is clamped, there are stresses and strains on various parts; and when it is fired while thus clamped, these are intensified and tend to destroy accuracy unless the operator is so



experienced that he can find the proper tension to give to the various clamping screws without spending hours on every individual rifle—which is what you or I would have to do, and even then finally give up in despair nine times out of ten.

Years of use, and several series of conclusive demonstrations, like the tests of match ammunition at Sea Girt, N. J., last May, have proved beyond doubt that the accuracy of the results in machine rest firing depends on the proper "bedding" of the rifle in its cradle or holder—which in turn depends on human skill. And accuracy is what is sought, not only by our own Ordnance Department, but by those of many foreign countries, and by manufacturers of rifles and machine guns.

Another device that almost everybody interested in rifle shooting has heard about is the "V" rest, which the late Dr. Mann, who designed it, called "a shooting Gibraltar." It is simply a block of iron having a deep V-groove, and set on a concrete base. A barrel (with breech mechanism) is clamped in two equal-sized rings and laid in the V, and when fired it recoils freely and may also turn slightly, owing to the reaction of the force needed to spin the bullet. By using a special heavy barrel, vibrations are practically eliminated and the accuracy is all that can be desired.

For testing ammunition the Mann "V" rest cannot be beaten. The most accurate known method of firing ammunition is from a special heavy barrel in the Mann rest. That is very fine, as far as it goes, but when we do that we are not firing from a rifle, and the results obtained with our special barrel are of little value with regard to rifles, important as they are with regard to ammunition.

So successful has the Mann V-rest method of shooting been that all experts agree in accepting the desirability of firing a rifle from the Mann rest. That this has not been done is due to the construction of rifles—especially military rifles. The rifle must be held in a tubular or ring holder; that much is evident, but how should it be held? If it is clamped in a manner similar to that used in the machine rest holder, the accuracy of this method could not be expected to be greater than with the latter.

How then should it be held? To answer that question with certainty, one should know definitely the conditions under which a rifle should be fired in order to obtain the utmost accuracy.

At present, however, few can claim definite knowledge of the multitude of factors present when a modern high-power rifle is fired. A study was therefore made in a narrower scope: the conditions for accurate shooting of a rifle from a mechanical holder in a V-rest, and as certain points became more and more obvious it became possible to formulate the requirements, as follows:

(a) The rifle barrel must not be stressed, nor even come in contact with anything outside of the rifle.

(b) The rifle must be held absolutely securely.

(c) Security of holding must be achieved without distorting any parts of the rifle or causing them to receive unusual or accuracy-destroying strains whenever the rifle is fired.

(d) The force of recoil of the rifle against its holder must be absorbed in one place, and that place as close as possible to the axis of the bore and to the base of the cartridge. The other places at which the rifle is held must not be affected by the recoil force.

(e) The rifle must be held at as few places as possible; and wherever it is held there must be no tortional resultant from the forces applied; in other words, the pressures applied must be as nearly as possible equal and opposite so as to neutralize each other and not affect the rest of the rifle.

(f) Finally the holder itself must be (1) light enough to be carried back with the rifle without accuracy-impairing strains on the points of contact; (2) elastic enough to "give" a little with the natural vibrations of firing, and yet (3) strong enough to be accurate—that is, maintain the axis of the bore constant even after a great number of rounds; (4) simple and not too expensive; and, above all (5), practical—that is to say, it must allow operating the rifle: loading, working the bolt, extracting, eecting, turning the cut-off or safety, etc.

In addition to these requirements, Major Wilhelm, the Ordnance representative on the Infantry Board, directed that the holder be so designed, if possible, as to accommodate rifles fitted with various types of telescopic sights.

The above sketch shows a Ring Holder deigned to meet these requirements.

Aircraft Armament Division

Continued from Page 228

Page airplanes and incorporate the Weed shackles in the design, allowing the suspension of bombs horizontally inside of the fuselage.

Aircraft Machine Guns.

Under Aircraft Machine Guns, one model of the new .50-caliber Aircraft Machine Gun has been completed at the Colt Manufacturing Company and is now undergoing preliminary tests. As soon as the preliminary tests are completed, synchronization, endurance and air tests will be conducted. The modification of the Browning Aircraft Machine Gun, Model 1918, is well under way at Springfield Armory, and one hundred and thirty-three guns have already been delivered. The design of the Browning Aircraft Machine Gun, Model 1919, is progressing. This gun will be identical with the modified Browning 1918 Aircraft Machine Gun, excepting that the design has been developed with the view of making it a new production job rather than a modification of existing equipment. A design of a modification of the 11-mm. Vickers Aircraft Machine Gun has been tentatively completed and one sample gun has been undergoing test for sometime. This modification has been undertaken with the view of reducing the size of the barrel jacket, adding a French speeding-up device, adding a trigger motor which can be operated by the mechanical synchronizing gear developed by the Air Service and making such adjustments as are required to make the gun interchangeable with other mountings. The purpose of these modifications has been to obtain a modified gun which would be satisfactory for mounting in the new types of aircraft developed by the Air Service, to improve the functioning of the gun and obtain a high rate of fire.

Considerable work is being done at Springfield Armory toward the development of the 37-mm. Automatic Aircraft Gun. Effort has been concentrated on the modification of the Baldwin Gun to improve its functioning and make it more adaptable for aircraft use. Many difficulties in the development of this gun have been encountered which have been slowly overcome and now it appears that a gun has been evolved which will function satisfactorily on the ground, as far as it has been possible to ascertain this from facilities available for testing such a weapon at Springfield. As soon as it is assured that reliable functioning can be expected of this gun, on the ground, it will be exhaustively tested in the air.

Edwin A. Shepherd
Manufacturers Agent
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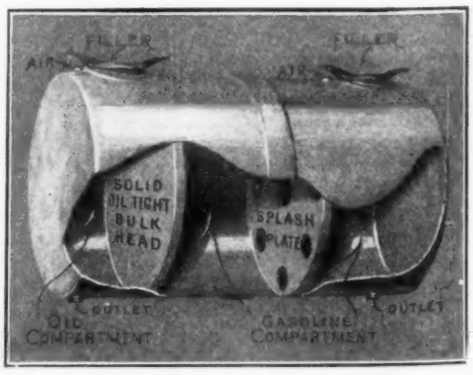

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